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Irrigating Prior to Harvesting.

In a field of H 109 plant cane, recently harvested at the Waipio Substation, interesting observations have been noted on the effect of the interval between the last irrigation and the time of harvesting, on the quality of the juices. The soil in the fields reported is very uniform, and, with the exception of Section 27, the land is level. Soil samples were taken to a depth of six feet just after the field was harvested.

The following table summarizes the observations:

Field	Days Since Last Irrigation	Average Moisture Percentage to 6 Ft.	Quality Ratio	Cane per Acre	Sugar per Acre
A	40	25.90%	8.51	64.98	7.64
D	45	25.30	8.36	55.73	6.67
C	60	25.20	7.47	52.28	7.00
Section 27	64	23.32	7.92	53.71	6.78
F	78	22.60	8.07	49.79	6.17
B	80	22.27	8.05	57.05	7.09

The best juices were obtained where the water was shut off sixty days before harvesting, and the poorest where water was stopped forty days before harvesting. The juices from the eighty-day fields were poorer than the sixty-day and better than the forty-day juices. In other words, where irrigation was continued until forty days before harvesting, the cane was apparently too green, while removing the water eighty days before harvesting caused some deterioration. Sixty days before harvesting appears to be the optimum time to shut off the irrigation water to obtain the best juices, at least for short cropping with H 109 grown under Waipio conditions. The fields where these observations were made were plant cane of 13½ to 14 months' growth, with the exception that Field F was short ratoons of 12 months' standing.

R. M. ALLEN.

Leafhopper Investigations on Hawaii.

By C. E. Pemberton.

The following is a preliminary report on the results of my investigations of the sugar-cane leafhopper on the Island of Hawaii, with particular reference to the various factors entering into the causes of its continued abundance on this island. The period covered by the work herein reported has extended from June 22nd to July 26th, 1919, inclusive.* Most of this time has been spent in the Mountain View section of Olaa Plantation. Two short visits have been made along the Hamakua coast. The particular condition of the fields visited at the other plantations, in addition to those on Olaa Plantation, will be reported later, the present report being confined to the general results of the biologic and other studies of the leafhopper and insects associated with it, together with methods of control that have been under investigation during the past few weeks.

Occurrence on Grasses and Sedges.

Perhaps the most interesting point that has come to light in the studies of the leafhopper at Mountain View, is the determination of the fact that this insect may attack and live on other plants than the sugar cane. At the present writing I know of no records of the hopper attacking anything but sugar cane in Hawaii, and the information is not at hand, if there is any, regarding other host plants harboring it in Australia.

During the past few weeks hopper eggs have been found in no less than seven different kinds of grasses and three different species of sedge-like plants. Material of each of these plants is now in the hands of Dr. H. L. Lyon for determination. Several of the above varieties of grasses are very common, one being the familiar "Hilo Grass," and one the so-called "Red Top" which is abundant in Olaa and along the Hamakua coast and probably over most of the lowland portions of the Islands. One of the grasses, no name of which I can give at present, seems particularly favored by the leafhopper for egg-laying. On July 22nd, in about twenty minutes' time, I was able to find 25 flowering stems of this grass in each of which various numbers of leafhopper eggs were found. The 25 stems contained 69, 66, 84, 20, 19, 11, 48, 14, 7, 91, 3, 2, 135, 103, 44, 9, 22, 27, 31, 14, 50, 13, 7, 28 and 2 egg punctures, respectively. Some of the punctures contained only egg-shells, the hopper having already hatched out, but all others contained hopper eggs in various stages of development, some being parasitized by *Paranagrus optabilis*. I find this to be one of the most common grasses at Olaa. Most of the grass covering the large acreages of pasture lands separating Olaa and Pahoa is of this species.

The subject of hopper attack upon other grasses than the sugar cane is one of great importance, and the investigations so far have really only commenced. The data at present is meager, but convincing, and it should not be out of place to present here the following summary of those grasses, in addition to the one above discussed, which I have already studied at Mountain View.

* Since the writing of the present report, much additional information has been secured, more fully completing and substantiating the statements and subjects above treated.

In "Honohono" grass, only one egg-puncture, containing 6 eggs, all parasitized, has been found.

In the "Hilo" grass, eggs are no doubt very frequently deposited. During about one hour's searching in this grass on July 22nd, 14 stems were found containing hopper egg-punctures. In the 14 stems there were 2, 5, 2, 1, 2, 5, 4, 10, 4, 4, 1, 4, 1 and 9 egg-cavities, respectively. Several of the punctures were opened and found to contain fresh, mature, parasitized and unparasitized hopper eggs. The stems were then placed in a jar and already both hoppers and their parasites have been bred out.

In a fourth species of grass, not common, but growing luxuriantly where found, 9 stems were found in a half hour's search, containing 12, 6, 3, 5, 11, 12, 3, 6 and 12 hopper egg-punctures, respectively. As in the above, these punctures contained eggs, some of which were parasitized.

A fifth grass, which for convenience I am calling "Red Top," owing to the frequent reddish tinge along the margins and tips of the leaves, seems quite favored by the hopper. In an hour's search in this grass, 17 stems were found, containing 12, 4, 3, 1, 7, 4, 13, 16, 21, 1, 8, 3, 1, 8, 4, 2 and 3 egg-punctures, respectively. As in the other grasses, eggs were abundant in the punctures.

Another grass, not particularly well distributed, but a rank grower where found, was examined on July 23rd. In one locality, in 45 minutes of effort, 20 stems were found, and in which 3, 2, 1, 1, 2, 2, 7, 2, 3, 1, 3, 2, 3, 5, 2, 2, 2, 3, 2 and 2 egg-punctures occurred, respectively. Eggs were plentiful in the cavities. This grass grows from one to two feet high, but all of the egg-punctures, without exception, were in the stems from 1 to 2 inches from the ground.

The seventh grass in which eggs were found is a plant with large, broad leaves, pointed and ridged or corrugated longitudinally. In this the eggs were laid in the leaf midrib. It grows very large in some of the gulches along the Hamakua coast. Eggs were found in the leaves of one plant at Mountain View. From several of these leaves, cut into thirty 3-inch pieces, a total of 44 leafhoppers, 76 of the parasite *Paranagrus optabilis,* and one of the parasite *Ootetrastichus formosanus,* were bred. This represents about 125 hopper eggs in the leaves when picked.

Of the three sedge-like plants in which hopper eggs have been found, one is very prevalent along the roadsides and in the pastures and along the edges of the canefields and has been found in the grass adjoining the road all the way from Olaa to Honokaa. The eggs of the hopper are placed in the smooth flowering stem. From 60 of such stems, collected on July 4th, a total of 198 hoppers and 146 *Paranagrus optabilis* have hatched out. This means that there were at least 344 hopper eggs in these stems when collected. In the yard in front of the house in which I am staying in Mountain View, stems of this sedge can be found in which there are hopper eggs, some parasitized and some not, and some fresh and some mature. This yard is 75 yards from the nearest cane. Two other sedges, which are probably not so common as the above, attract the leafhopper sufficiently to receive its eggs. One is a large plant, growing from 4 to 5 feet high. Some leaves and flowering stems of this, collected July 2nd and cut into forty-six 5-inch pieces and placed in a covered jar have already been productive. From these I have bred out 159 hoppers, 119 *Paranagrus* (the ever-present egg parasite)

and 15 *Ootetrastichus formosanus* (the Formosan egg parasite). This shows that these few leaves contained a total of at least 353 leafhopper eggs when cut. In this computation the 15 *Ootetrastichus* represent an average of 5 hopper eggs per parasite.

The presence of parasites in many of the eggs found in the various grasses and sedges, is encouraging. It shows one good way in which parasites are held in the vicinity of harvested canefields, where no cane may be present for some time and where no hopper eggs or parasites would be expected to be present were the grass not there.

In considering the above information, certain features of the work must be particularly borne in mind. All of the research into this subject has been so far made only in canefields, adjoining them, or in their immediate vicinity. No time has as yet been available for a study of grasses distant from canefields or even more than 300 yards from the cane. The fact alone that the hopper will deposit its eggs into these various grasses and sedges in the open fields, even though in or near cane, is of great significance. These eggs hatch normally, and what is more important, the young hoppers can feed on this grass and mature in it. I have proven this point already on "Hilo Grass" and have fed a hundred or more hoppers from hatching to maturity on this grass alone. I feel convinced that the other grasses will serve as well or probably better than the "Hilo Grass" as food for the young hoppers. I have found young hoppers in fairly large numbers in most of the grasses above discussed. It is now necessary to determine the extent to which the hopper occurs in these various grasses, etc., at gradually increasing distances from canefields. The solution of this point is important as well as a determination of the extent to which it remains in grasses adjoining canefields, and particularly in recently-harvested fields. As the distance is lengthened between the grasses and the canefields, I would anticipate a rapid decrease in the number of hoppers or eggs present, and a zone soon reached where none could be found.

Enemies of Leafhopper Parasites.

Of no less interest than the finding of new hosts of the hopper, is the wholly surprising result of a study of possible enemies of the parasites of the leafhopper. One enemy of real importance has already been found, and one other is present, though not now sufficiently numerous to be of danger. These two enemies of our best hopper parasite are a large black earwig, *Chelisoches morio,* so commonly seen in the canefields of the rainy belt on Hawaii, and a green lace-wing fly, both generally considered beneficial insects because of their insect-feeding habits. Of the two, the earwig is of much greater importance because much more numerous.

Observations on the habits of the earwig commenced a short time ago and only a few days have as yet been devoted to this. It feeds very readily on the adult *Paranagrus.* One reliable method of determining the food habits of an insect which chews and swallows all or most of the solid parts of its food, is by capturing such insects in the localities where they are living naturally and examining their intestinal canal immediately, or by confining them as soon as collected, in clean glass vials or tubes and later examining microscopically all

of the excrement cast during the next 24 or 48 hours. This latter method has been adopted in a study of the earwig. To date 26 earwigs have been taken from stools of cane where they were crawling about, each placed in a separate vial and all excrement which was cast, carefully examined under a compound microscope from 24 to 48 hours later. This is a slow but sure process. Of the 26 individuals collected, 19 were found to contain remains of the leafhopper parasite *Paranagrus optabilis*, in varying quantities. In some the remains of parasites were exceedingly abundant. Large numbers of pieces of *Paranagrus* wings, legs and other body parts could be clearly recognized. In a few there was nothing present but parasite remains. In most of them the remains of parasites were mixed with portions of other insects which the earwig had been eating, which included leafhoppers. In view of the fact that seldom more than 4 or 5 *Paranagrus* adults have been seen at one time on the leaves of cane where these earwigs have been collected, but great numbers of hoppers present, it is rather startling to find so many *Paranagrus* present in the excrement of earwigs. It suggests the strong possibility that they may prefer parasite to hopper as food. In fields where the parasitism may sometimes rise very high and where the adult parasites must then necessarily become very numerous if hopper eggs are abundant, great numbers must be eaten by this earwig. As the hard parts of insects eaten pass through the earwig very quickly, it means that those individuals above collected that contained *Paranagrus,* had eaten these parasites within only a few hours previous to the time of collection. How many had they eaten during the month or more of hours that they had been actively living previously? The earwig has the habit of frequently crawling into the crown of the cane stalk. Here its clusters of 10 or 15 eggs are often found and here its progeny of young are often found crawling actively about. The young feed upon the parasites as well as do the older earwigs. It is significant that *Paranagrus* can usually be found ovipositing into fresh hopper eggs near the bases of newly opened leaves in this crown, just where the earwigs are so often present.

In addition to the record on the 26 earwigs above cited, 3 were collected from a crack in the door of the parasite hatchery of the Hilo Sugar Company on July 14th. They were placed individually in vials and the excrement from them later examined. As parasites were very numerous about this hatchery, the excrement from each of the 3 earwigs was found to contain large quantities of parasite remains.

The earwig also feeds upon leafhoppers and has always been considered beneficial. It is distributed all over the islands, but is most numerous in the cane fields of Hawaii where rainfall is heavy. It will be investigated carefully and conclusions reached, if possible, as to which outweighs the other—its good or its bad habits.

The other insect found feeding upon *Paranagrus* adults is a green, lacewing or Chrysopid fly. The conclusions in respect to it are confined to a single observation also only very recently made. But this observation shows a need for further study. One larva of this fly was seen crawling on a cane leaf on July 13th and watched for 5 minutes. During this short time it was actually

seen to capture and suck out the body fluids of 4 *Paranagrus* adults. This, of course, killed them. The larva feeds with a pair of long, sharp, sickle-like mandibles, with which it grasps its prey and through which it sucks the fluid contents of the host. The larva, while being observed, ran rapidly over the leaf midrib, and each *Paranagrus* caught was in the act of ovipositing when caught. It feeds on other insects including leafhoppers.

If, after study, the above-mentioned enemies of *Paranagrus* are considered detrimental, the practice of trash burning in the Mountain View section should be of help in ridding fields of the earwig. There is no indication of any disease present in the parasites. The possibility of other insects and of spiders feeding upon *Paranagrus* will be investigated.

Effect of Excessive Rainfall Upon Leafhopper Parasites.

Mr. Muir of the Station staff, has frequently advanced the theory that heavy and continuous rains are detrimental to the delicate parasites of the leafhopper. Splendid opportunity has been afforded during the past few weeks fully to confirm this view. Though the rainfall has not been heavy during June and July of this year, still several periods have passed in which more or less continuous rain fell over several days. The adult *Paranagrus* was carefully watched in the cane fields of Mountain View during the rains. They could be readily found struggling on the upper surface of the wet leaves, endeavoring to get a foothold, crawling in all directions and making no attempt whatever to lay their eggs. Frequently they have been found dead at the base of the leaf on the upper surface near the stalk where they have been washed by the rain. They show no apparent ability to select the lower and protected surface of a leaf during rain. Some, of course, are present on both sides of the leaves. Those on the lower surface, if quiet during the rain and until the leaves have drained off somewhat after a rain, may not be killed; but in long-continued rain not many of the adult parasites in a field can long survive. Thousands, of course, are present in the eggs in the leaves, and are not affected by the rain, and are hatching out hourly, but if rain is falling many of these never can oviposit. On several separate occasions, the day following 3 or 4 days of rainy weather has always shown a decided reduction in the number of adult parasites present on the cane leaves, and in comparison with this, the sequence of 3 or 4 days of continued good weather, has been decidedly noted to be accompanied by a coincident accumulation of living parasites on the leaves. As the parasite normally lives several days, such a period of good weather simply permits all parasites hatching out during those days to be present in the cane, alive and actively laying their eggs. At the present time the parasites have accumulated well in the district. Three months have passed during which there has been insufficient continued rainfall to hinder the work of these parasites and the parasitism in the hopper eggs is very high. Without a fall or winter of excessive rainfall the present quantity of parasites in the fields should be sufficient to bring great relief to the fields from hopper attack during the next six months. Some objections have been raised against the theory of rainfall being destructive to the work of the egg parasite. The objections are reasonable and have some weight.

However that may be, the above noted observations made before, during and after even moderate rainfall, have consistently and clearly demonstrated the detrimental effect of rain upon *Paranagrus*. We must yet study very carefully the conditions of these fields during the few weeks immediately following periods of continued and heavy rainfall, such as during July, August, November and December of 1918, when these months had at Mountain View, 38.88, 19.24, 24.32 and 37.16 inches of rainfall respectively.

The question has been raised in regard to the effect of rain upon the leafhopper. It has a most certain ability to seek shelter on the under surface of the leaf. Most young hoppers, even in the best of weather, crawl to the shaded, lower leaf surface and remain feeding there. *Paranagrus* may fly a few minutes after hatching and will expose itself to rain and water on the leaves to a much greater degree than the young or adult hopper. It is quite evident to those familiar with the leafhopper situation on Hawaii, that leafhopper troubles are greater where the rainfall is greatest, with occasional sporadic exceptions, and gradually decreases as the sections of lighter rainfall are reached. More than one factor may be accountable for this prevalence of leafhopper in rainy districts. Several of these factors are already recognized. The action of rain on the parasites is one, the work of the predaceous earwig against the parasite is another, and it is quite possible that the rain, acting alone is insufficient to account for the repeated outbreaks of hopper. Though the rainfall cannot be controlled, the other factors may. A complete understanding of these, which might be controllable, may bring a decided relief from present conditions. Such an expectation is not necessarily visionary and stands wholly within reason.

Contamination of Young Fields by Old Fields and Advantages of Field Isolation.

A study of the varied situations and conditions of the widely separated sections of Olaa Plantation throws very encouraging light upon what may be expected in the future after further experiment has been conducted. Fields E Y and Kipuka No. 2 are highly interesting for study. Each of these fields is isolated from all other cane by barren, pasture or forest land. Mr. A. J. Watt, whose long experience on this plantation enables him to speak with certainty, states that he has never known of serious outbreaks of leafhopper, during its entire history, in cane at Kipuka No. 2, and only once in Field E Y, and that about 4 years ago. Why is this? Field E Y is in the most elevated and rainy section of the entire plantation. It is planted with D 1135 cane, but at present the crop shows almost no leafhopper injury and the lower and dead leaves show no history of hopper trouble during the past year, when hoppers were so exceedingly abundant in almost all of the other fields of the Mountain View section. The isolation of these two fields (E Y and Kipuka No. 2), and the fact that all of the cane in each is harvested at one time, may explain their freedom from hopper trouble. After the cane is removed, the rattoon or plant crop following is not contaminated by migrations of hoppers from heavily infested, adjacent cane, as in most other fields in the Mountain View section. Some hoppers are there, however, and here we have the suggestion of their survival in the adjacent

grasses, in addition to stray uncut cane plants, before the young plant or rattoon crop is up.

The two above-discussed fields indicate good possibilities for relief from hopper injury in Fields 1-2-3 and 7. These are sufficiently separated from the other fields of the plantation to be but little affected by migrations from such fields. Field 7 is 1920 cane and Field 1-2-3 is a 1921 crop. By starting, in 1921, both sections at the same time, great profit should result. But little contamination should come to the young rattoon of all four fields, with the possible exception of one corner of Field 1-2-3. The importance of adjoining grasses will of course be investigated. The objection to such a recommendation is the danger of fire, where fire-breaks in the nature of alternating fields of young and old cane are absent. In view of the wet condition of the Mountain View section and the location of the two sections under consideration, the point is worth careful attention, particularly when the favorable demonstration of such a process is already before us in Fields E Y and Kipuka No. 2. The chance of fire seems worth taking.

Where possible, other plantations suffering from leafhopper attacks, should study the location of their fields and the succession of crops thereon with the same idea in view as above treated. Whenever possible, areas isolated by gulches, pastures, or barren and forest land, should be planted or rattooned in a single block or crop. The subject of contamination of young cane by hoppers from older, adjoining cane, is important and easily understood when the details of hopper migration are fully comprehended, as discussed below.

Leafhopper Migration or Flight.

On several occasions during the past few weeks, the so-called "migration" of adult hoppers has been carefully followed. This has been described before by the Station entomologists. A particular flight which I observed on the evening of June 28th clearly indicated the importance of a knowledge of this habit. Great numbers of hoppers were flying on this evening from some high, D 1135 ratoons in Field 4-5 of the Mountain View section of Olaa Plantation. By walking along the road separating the high ratoons from an adjacent field of young plant cane, the hoppers could be easily seen and the character and distance of flight clearly noted. The evening was warm and the air motionless and quiet. About 6:15 p. m. many hoppers were noticed on the tops of the cane leaves, crawling out to the very tips. At about 6:30, when it was approaching darkness, they commenced jumping upward from the leaves and flying. The flight of each individual was slow and easily followed at a moderate walk, was usually in an almost straight line, sustained, low and nearly always extended for from 50 to 200 yards. Seldom was an individual seen more than 10 or 12 feet above ground. Many were followed from the high cane out over the young plant cane until they fell or alighted. It was easy to follow an individual. None that were followed from start to finish flew more than 200 yards. No particular direction was taken. Some were flying from the young cane into the tall cane and many were flying out over a field of pasture land containing

grass, tree-ferns and various weeds. One was found flying in this pasture 300 yards from the nearest cane. From present knowledge, it probably started somewhere in the grass. In going into the pasture from the cane, the number of flying hoppers rapidly decreased, until at a 150 yard radius a flying hopper was seldom seen. The flight is slow, labored and seems to terminate with exhaustion. It is not a simple hop or flight from one stalk or row to another. Here is an undoubted, instinctive tendency for flight, induced by unknown causes, at a certain time and only at a certain time of day and seemingly in no particular direction. This last point is highly interesting and serves to show how young or tender cane does not necessarily attract hoppers but simply harbors or holds those which by chance fly into it. It also shows that a center of dispersion, such as half-grown field of heavily hopper-infested cane, feeds all adjacent territory with hoppers. Hoppers do not necessarily move in a mass in one direction in one flight and later take up another flight in the same direction. The effect of wind on flight has not been observed. No flights have been seen during rainy or moderately windy evenings though the hoppers have been frequently watched on such evenings. At such times the hoppers were quiet, low in the cane and seldom seen moving up the leaves towards the light.

To one viewing the flight of thousands of leafhoppers at dusk, the impression should be strongly felt of a need in these islands of more night-flying enemies of not only mosquitoes but of hoppers as well. When the great acreage of cane is considered, with a knowledge of the fact that the cane leafhopper is ever present in all of the cane in varying quantities, and that they are nearly always flying at dusk in great numbers in some or many localities, the opportunity for aid from such predators as bats and swallows is most striking. It is really remarkable that no attempt has at least been made to introduce two such beneficial and perfectly harmless aids to the welfare of mankind, in spite of such arguments as have been advanced in respect to the futility of an attempt.

Preference for Certain Conditions of Cane.

The preference of the leafhopper for particular varieties of cane and for the different conditions prevalent in these varieties in various fields, has been kept in mind during the examination of all fields and plantations so far visited. Some conclusions have been drawn which may be of interest and value. Certain fields at Mountain View which I have examined during the past month, belonging to independent planters, are comparatively free from leafhoppers. This I ascribe to less attention to cultivation, weeding and the application of fertilizer, than is given the fields under the supervision of Olaa Plantation. The cane in these independent plots has not grown rapidly, the leaves are not so tender, dark green or luxuriant as on the Plantation, and the green grasshopper or locust *Xiphidium varipenne*, which feeds on the hoppers, becomes much more numerous where the grass is not so consistently kept down. I do not believe the hoppers oviposit as much in the slower-growing, tougher cane, even though they may migrate to it as readily as to the tender cane in the better cultivated fields. This reduction in the amount of oviposition, combined with the presence of greater numbers of the *Xiphidium* where the grass is not cut regularly, explains

the absence of hoppers in poorly cared-for fields. Biologically it is interesting and suggestive, though at present it is considered safest to intensively force as heavy a growth of cane as possible. During a recent visit to Honokaa Plantation, where the leafhopper is very scarce, one field, and only one, was found where the hopper was at all numerous and here there was no apparent injury. The field was of H 109 cane, one year old, growing at the lowest elevation on the plantation, and very tall, vigorous and rapid in growth. This cane had evidently always received an abundance of water and here the hopper had oviposited and accumulated sufficiently to have become numerous and had favored this cane to all others in the vicinity, the others having tissue somewhat tougher. Conditions here for the development of the leafhopper parasites are ideal, but this field strongly indicates that even under such ideal conditions for the parasites, an unusually rich and tender growth of cane will permit the hopper frequently to get ahead of its parasites to some extent. At the Mountain View section of Olaa Plantation, practically all of the cane now growing has the same qualities so desired by the hopper, that this H 109 field had at Honokaa. In all of the hundreds of acres of cane in the Mountain View section that can be viewed at one time, no cane can be seen, even in small spots, that is not of a rich, dark-green, healthy color. This, in combination with the detrimental action of the excessive rain upon the parasites and the work of certain predaceous insects, sufficiently accounts for the continued prevalence of the hopper in Mountain View. I am convinced that no other one factor is more important in accounting for the reduction in yields of cane at this place, during recent years, than the depredations of the leafhopper.

The subject of hopper preference for various types of cane and of its tendency to oviposit more frequently under certain conditions, will be further investigated.

Effect of Fumes of Volcano on Leafhopper Parasites.

The possible effect of the fumes of the Volcano upon the leafhopper parasites at Pahala Plantation has often been discussed. An experiment with regard to this has been completed. About 10,000 *Paranagrus optabilis*, from 1 to 12 hours old, bred from the hopper eggs at Olaa, were divided in half, each portion being placed in a glass chimney 7 inches long and 3 inches in diameter, and closed at each end with a cloth cover. One-half was left in a room at Mountain View and the other half taken to the Volcano and placed within 20 feet of a steam-crack liberating sulphur fumes. These parasites were allowed to remain here 7½ hours, the cloth covering at each end of the chimney being changed to a cheese-cloth to permit ample circulation of the fumes through it. The chimney was then placed in a box and taken to a room at the Volcano House and returned to Mountain View the following day at 3 p. m. A comparison was then made of the two lots. All of the parasites in the chimney left at Mountain View were dead, while about 150 were still alive in the lot that had been exposed to the sulphur fumes at the Volcano. With no food or water, *Paranagrus* normally lives not more than 2 days. No food or water was given either lot in this experiment. The above then shows that the fumes apparently had no

injurious effect upon the parasites, even though placed within 20 feet of a crack emitting sulphurous fumes. They outlived those which remained at Mountain View simply because the cooler temperature at the Volcano retarded their activities in the jar and their energies were less expended and their life consequently lengthened. In view of the results, it hardly seems probable that fumes from the Volcano will injure leafhopper parasites at Pahala Plantation, 17 or 18 miles distant, though the supposition seemed wholly within reason.

Miscellaneous Notes on Leafhopper.

Some conclusions have been reached in regard to the advisability of stripping the low, green leaves in hopper infested fields and allowing them to remain on the ground, as a measure to reduce the number of hoppers in a field and still not interfere with the abundance of the parasites. Present indications are that this will not work the expected result at Olaa and particularly in the upper fields at Mountain View. The frequent rains and high humidity here keeps even the old leaves, in which no trace of chlorophyll is present, in a soft condition, thus permitting all hoppers and parasites in such leaves to hatch out. The cutting of low leaves from the cane and placing them on the ground will not then interfere with the emergence of everything in the leaves. From 43 dry leaves pulled from some high ratoons of D 1135 cane in Field 6 on July 1st and placed in a jar without moistening, a total of 2672 *Paranagrus* and 646 hoppers emerged. This shows that there were at least 77 hoppers eggs per leaf in these dry leaves hanging on the stalk and that 80% of these were parasitized, and it further indicates that there is little or no natural mortality of hoppers or parasites in such leaves because they have become dry in color. Such a mortality does occur, however, in plantations on Oahu where the rainfall and humidity are much lower.

Another collection of 34 leaves from the same stalks of cane as the above, but taken each just below the lowest green leaf on the stalk, has given results worth recording. These leaves contained 9364 hopper eggs, 6611 of which were parasitized by *Paranagrus*. This represents 275 eggs per leaf of this type, and a 70% parasitism, and shows the importance of using such leaves in the parasite distribution work now going on at Olaa and other plantations. There can be no possible injury to the cane stalk in the removal of leaves of this sort, and the abundance of living parasites in them clearly warrants their use in sled-boxes and cages used for hatching out parasites. Such leaves are already being used for this purpose at Olaa Plantation.

Twenty-five more leaves from the same stalks as the above lots were collected, were taken on July 1st, these being the selected green leaves from these stalks. They were taken for the purpose of comparing the abundance of hopper eggs and parasites therein, with that of the lower, brownish or dry leaves. These contained 8017 eggs, 6899 of which were parasitized by *Paranagrus*, or 320 eggs per leaf bearing an 86% parasitism. The three lots of leaves just discussed give interesting data. Further information on this subject will be secured.

Experiments have been under way to determine the distance and rapidity of dissemination of the leafhopper parasite *Paranagrus optabilis*. The results

so far are uncertain, as the finding of parasitized hopper eggs in grasses has complicated the experiments.

The proportion of sexes of the leafhopper at Mountain View has been studied. Of 5361 hoppers collected in cane fields, only 1488 or 27.7% were males. No infertile eggs have been found in the cane, however, and the hopper is not parthenogenetic, that is, the female does not deposit fertile eggs without being mated.

Of the 5361 hoppers above referred to, only 43 were parasitized by the Pipunculus flies. No parasite of the family *Dryinidae* have been seen about Mountain View and the *Ootetrastichus* egg parasites are scarce, though *Ootetrastichus formosanus* was much more numerous in the latter part of July than in *June*. This increase of the *Ootetrastichus* is very probably due to the coming on of warmer weather.

Green Locust, Xiphidium Varipenne, Important Enemy of Leafhopper.

The importance of the green locust or so-called "Green Grasshopper" *Xiphidium varipenne* as an enemy of the leafhopper, has been already referred to by other entomologists of the Station. Additional information has been obtained, further indicating its importance as a highly beneficial insect. The intestinal content of a total of 67 individuals, collected in cane fields, has been examined under the microscope. Briefly, of this number, 53 contained remains of the leafhopper in varying quantities, but generally in large amounts. In two cases a *Paranagrus* wing was present and in one very small young locust a large number of remains of *Paranagrus* were found. The record of this last individual makes it necessary to continue the study of the habits of this locust very carefully before its absolute value can be asserted. It is a heavy insect feeder and occurs in the grassy pastures and along the borders of the cane fields of Hawaii in enormous numbers. The presence of it in such great quantities in the pastures, can readily account for the absence of most insects there and also for the scarcity of leafhoppers which may breed out from eggs deposited in this grass or which may have migrated from adjoining cane. This is clearly shown in one pasture in Mountain View adjoining Field 1-2-3. Here there are straggling wild stalks of cane growing in the grass. Some hoppers frequently migrate into these stalks, for a few adults can usually be found there, and eggs are deposited, but all young that hatch out quickly disappear and no well-developed young hoppers have as yet been seen on these stalks. The *Xiphidium* nymphs and adults are so numerous in this grass that no young hopper can long survive, and no doubt the migrating adults coming into this field almost daily, are captured and eaten before many days elapse. In several cane fields examined along the Hamakua coast and at Olaa, where grass has been growing for some time and where *Xiphidium* has accordingly accumulated in large numbers, the hoppers were noticeably scarce. The coincidence is interesting. As this locust deposits its eggs beneath the leaf-sheaths of various grasses, and as it requires nearly a month for the eggs to develop, the frequent removal of grass in the young cane fields greatly retards the natural increase of this species in such fields. This accounts for its greater prevalence in grassy, uncultivated pastures and its

scarcity in young well-cultivated fields or old cane fields where grass does not grow and where the light is somewhat excluded. Where hoppers are present in large numbers, immediate relief should result from the large collection of these "green grasshoppers" and their distribution into the cane fields. The virtues of this insect as a direct enemy of the hopper are undoubted. All conclusions in regard to its final disposition must be withheld, however, until its selection or general avoidance of *Paranagrus* as food is determined.

Control-measures Against Leafhopper on Olaa Plantation.

Encouragement and advice is being offered at Olaa Plantation towards the use of contact sprays against the leafhopper. Such work would be purely experimental. It is felt that there are yet possibilities in the application of a good contact spray in young fields where hoppers are present in great numbers, clearly visible and within reach of such sprays. Such a method of combating the hopper in the past has been wholly discouraged and suppressed by discussion and argument and probably through the great success at most plantations of the introduced parasites. The use of sprays has not been eliminated yet through failure in actual experiment. It should not be considered impractical in localized young fields until careful tests have demonstrated the impossibility of relief in this direction.

The adoption of a general policy of parasite distribution on Olaa Plantation has attracted much attention. The methods of collection and distribution of these parasites at Olaa have been under careful observation during the past few weeks, in order to ascertain, if possible, the value of such work and to determine wherein changes or improvements could be made. In addition to the building constructed some time ago at Pepeekeo Plantation, to acquire the same results striven for by Olaa Plantation, the Hilo Sugar Co. has recently constructed a carefully-made parasite hatchery, modeled much after that at Olaa and which is now under operation and being persistently attended to.

The nature of this work undertaken at Olaa has been already explained by other entomologists of the Station in their reports to you. The attached photographs, secured through the courtesy of Olaa Plantation, Hilo Sugar Co., and Pepeekeo Plantation, with accompanying descriptions, will perhaps explain more fully what is being done and suggest to other plantations how to proceed with this work in case they decide to do so. After much discussion, study and thought into this matter, I feel convinced that it has many good features. We already have a perfect demonstration of the great value of the leafhopper parasites, and we know full well that in most cases where they get into a field where hoppers are present the hoppers are soon checked and reduced to a minimum, and that the prime factor responsible for this is the work of these parasites. In most large fields of cane where the hoppers have been abundant for some time, the parasites are already so enormously numerous there that little can be done within reason to materially increase the number. In one such field, recently examined, as many as 7000 parasites hatched out in a few days from about 30 leaves collected. It would hardly do to spend time and money in attempting to increase the number of parasites in this field by even one per cent, for there are 213 acres of such leaves in this field.

Other fields are found, however, where the hoppers are not yet numerous,

where there are few eggs, and where, in consequence, there are few parasites. In such fields, both parasitized and unparasitized eggs are present in small quantities. By liberating parasites here, through artificial distribution, the percentage of parasitism should quickly be raised and frequently almost doubled. This will give the hopper much less chance of gaining a headway during the coming months. It is probably the only time when it can be checked by an artificial dissemination of parasites in a comprehensive manner. This is at the start and generally when the cane is from one to three months old. The distribution of parasites in all young fields should be an established policy in all plantations suffering repeatedly from hopper attacks. Sometimes, because of the particular location of the field and of the conditions surrounding it, such distribution will not materially help, for parasites as well as hoppers may be already coming in from an adjoining field of older cane heavily attacked by hoppers. In the absence of a certain knowledge that such fields may not benefit from the placing of parasites in these fields, the chance must be taken and all young fields supplied with every available parasite, as consistently as the application of fertilizer, of cultivating or of hoeing. Many chances are taken in most agricultural pursuits. Here is one chance that has too much reason back of it to warrant its dismissal. The field that most needs the parasites will thus get them at the right time, and great assistance will result, even without our realization of it.

Field 1-2-3 of Olaa Plantation is being given a strong test in the value of this artificial distribution of parasites. The lower portion of this field, planted to H 227 cane on April 4th, 1919, should be partciularly benefited. The parasites are here being distributed by placing cane leaf midribs, containing large numbers of parasitized hopper eggs, in sled-boxes of the type shown in Illustration No. 1, and in the manner described for its use. The leaf midribs are collected from fields of large cane where both hopper and parasite are now very numerous, the leaves being the lower ones on the cane stalks. In this way it is estimated that each sled supplies, every two weeks, as many more parasites to the field of plant cane as are already naturally hatching out here every two weeks in each 500 yards of growing cane, and this without any addition of hoppers. Further data on this are being secured. In Field 1-2-3 there will be one sled for every two acres of cane. In addition to the sled-box distribution, parasites have been taken from the general hatchery shown in Illustration No. 3, and liberated in this field in large numbers.

Another system of hopper control considered by the Olaa Plantation, with good reason back of it, is that of removing a certain number of the lower leaves from each stalk of cane where hopper eggs are plentiful, removing these leaves to the parasite hatchery, breeding from them the parasites and returning these parasites to the field without returning the young hoppers which also hatch out. This reduces the number of hoppers hatching out in the field and every parasite returned should increase the ratio of parasite to hopper.

In all of such work, both in the hatchery and in the field-sleds, great care must be given to the details or much of the benefit will be lost. Parasites accumulating in the jars at the hatchery must never be allowed to remain many hours in these jars. Here they soon reduce their vitality in flying and crawling about without food or water or proper surface upon which to rest, and unless soon lib-

erated will die or become greatly weakened and be of little use when liberated. The field-sleds need careful attention. Leaf mid-ribs should not remain in the boxes longer than three weeks, and should be immediately replaced. Spider-webs should not be allowed to accumulate either in the interior of the hatchery or in or over the field boxes. They do accumulate very rapidly if not watched and removed.

One other point in this work should be emphasized. This method of hopper control is of little or no value unless conducted on a fairly large scale. In placing boxes containing leaf midribs in fields of young cane just coming up, one box per every two acres is considered sufficiently effective to give the parasites a good start, and the start is what is mainly needed and striven for. Each box should contain from two to four thousand midribs, well infested with hopper eggs, and, as before stated, the midribs should be frequently replaced and the work continued for at least three months. By then, parasites should be well distributed and have reached a stage of multiplication wherein artificial additions will be of little further use. If hopper eggs are still scarce in the field after three months of artificial parasite distribution, any further liberation of parasites will tend to reduce the hoppers in such fields to a very low minimum.

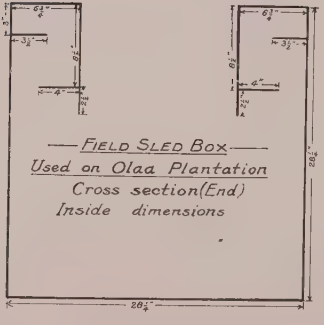

FIELD SLED BOX
Used on Olaa Plantation
Cross section (End)
Inside dimensions

Fig. 1.

FIELD SLED BOX USED ON OLAA PLANTATION.

This box is about 3 feet deep and 4 feet long, is placed on a sled, as shown in the photograph, and drawn by a horse to the desired locality. Four thousand cane leaf midribs, containing parasitized leafhopper eggs, are placed in this box at one time and changed about every two weeks. The leaf midribs are collected from fields where cane is well grown and hopper and parasite both abundant in it. Only the lower green leaves are taken. The box is narrow enough to be drawn between the cane rows. The galvanized iron roof furnishes protection from the rain.

At the top of the box and also inside just below the top, a double rim is placed, forming the so-called "Hopper-dodger," somewhat as shown in the cross-section of the box.

This prevents the young hoppers, which hatch from the midribs, from crawling out of the box. The young hoppers do not fly. The parasites, however, may fly out of the box immediately upon hatching from the midribs.

One foot from the bottom of the box, on the inside, is stretched a coarse wire netting, forming a false bottom. This holds the midribs off of the bottom of the box and prevents too much fermentation in the material put in.

In this manner parasites are easily distributed into fields of young cane, without increasing the number of hoppers. At the end of two or three weeks the old midribs should be removed and burned and fresh ones put in. Many living young hoppers may be in the box. In removing the old midribs, it is best to slide off the galvanized iron roof, lean into the box and place the old midribs into sacks and carry from the field and burn. Spider-webs must be frequently removed from just under the roof and in the box.

Fig. 2.

PERMANENT STATIONARY HOUSE USED FOR SPREADING PARASITES.

Beneath this roof are four large boxes constructed like the sled-box and operated in a similar manner. During the early growth of all cane adjoining or near such houses, these boxes are kept well supplied with leaf midribs, and from which thousands of parasites daily hatch out and distribute themselves in adjoining cane. Several of such houses have been in operation on Olaa Plantation. The sled-box is more practical and serviceable, however, because light, readily removed wherever desired, and much less expensive.

Fig. 3.

PARASITE HATCHERY AT HILO SUGAR COMPANY.

This building was modeled after the one at Olaa Plantation, and with some exceptions is almost identical with it. Here thousands of parasites are daily hatched out, accumulated in jars and then distributed to various fields over the plantation where needed. The building has been in operation only a few months.

Fig. 4.

CLOSER VIEW OF ONE SIDE OF BUILDING SHOWN IN FIG. 3.

This central portion of the building is divided into 14 compartments, 7 on each side. Each compartment is complete in itself and is separated from the adjoining ones by heavy, black roofing paper. The use of this paper for the internal partitions resulted in a considerable saving of lumber. Ample light on both sides of the building is necessary. The whole principle in collecting the parasites in the hatchery, is based on the inherent tendency of the parasites to go towards light, and the stronger the better.

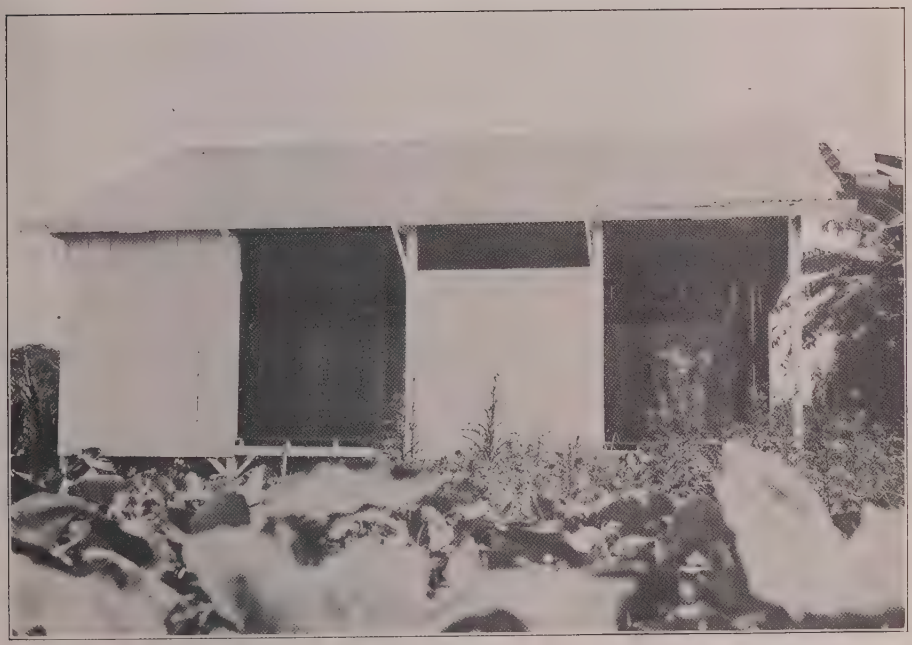


Fig. 5.

GENERAL PARASITE HATCHERY AT PEPEEKEO PLANTATION.

Fig. 6.

ONE COMPLETE COMPARTMENT OF PARASITE HATCHERY.

Showing hinged door on left opened and door on right partly opened, to show interior. Into it are stacked trays as shown. Each tray is a large, square, simple frame, over the bottom of which is stretched coarse wire netting. On each tray several hundred leaf midribs are placed every two or three weeks. When the doors are closed tight, the only light entering the compartment comes through the arrangement shown on the right half of the double door, the construction of which is also shown in Photographs Nos. 7 and 8.

The bottom of the compartment is fitted with a ventilator about 12 inches square, covered with a fine-mesh copper screen and arranged by a simple device to exclude the light. The bottom tray should be raised several inches to facilitate the entrance of air. The top of the compartment is also fitted with a ventilator permitting ample air circulation. It is also arranged to exclude all light The ventilators at the *top* and *bottom* of the compartment are absolutely essential for success.

From the midribs the parasites and hoppers constantly hatch out, but mostly during the bright sunlight hours of the day. The parasites seek the light while the young hoppers remain on the midribs and die there or crawl about in the box and accumulate on the bottom, where great numbers of dead ones can be found after the hatchery has been in operation for a few weeks. Few hoppers ever find their way into the jars which are attached to the door for collecting the parasites.


A

Fig. 7.

SHOWING DEVICE USED FOR COLLECTING PARASITES THAT HATCH OUT IN THE COMPARTMENT.

This is attached to one of the hinged doors. The only light that enters the compartment is through a vertical slit in the door about one inch wide and two feet long, as shown at *A*. The rectangular glass-fronted box shown in this photograph covers this slit. The glass-fronted box is separated longitudinally into two compartments, as perhaps better shown in Fig. 8. The box may slide to right or left as desired, to bring either compartment over the slit in the door. At the top of the glass box are fitted two glass chimneys, as best shown in Fig. 4 and Fig. 5, where they can be partially seen.

Parasites hatching out of the leaf midribs on the trays, go to the light and thus pass through the slit and accumulate in the section of the glass box opposite the slit. As soon as several hundred parasites have come into this compartment of the box, the revolving piece shown held by the hand in Fig. 8 is revolved, like a door, over the glass front of this side of the box, making it dark within this half of the box. The whole box is then slid to the right, bringing the left side of the box now opposite the slit in the door. The parasites in the right compartment of the glass-fronted box now move upwards towards the light coming into the chimney at the top, as seen in Fig. 4 and Fig. 5, and accumulate in the chimney, which is closed at the outer end with black cloth.

As soon as a chimney contains a sufficient number of parasites, it is taken directly into a cane field and opened to permit the escape of the parasites, or if it is desired to concentrate all parasites present in several chimneys, into one chimney, the device shown in Figs. 9 and 10 is used.

Fig. 8.

ANOTHER VIEW OF THE GLASS-FRONTED BOX

Into this the parasites are drawn from the interior of the main compartment containing the trays of cane mibribs. The hand is here shown swinging or revolving the pivoted door on the front of the box from the left to the right compartment of the box. This door or cover simply goes over the glass front and is used for darkening the interior of either half of the box in order to force the parasites to go up to the light at the top where the chimneys are placed. In this case the compartment on the right contains a sufficient number of parasites. It is being darkened to force these parasites up to the chimney on top, the end of which is covered with black cloth. The compartment on the left is being exposed to light and has been brought in front of the slit into the main hatchery.

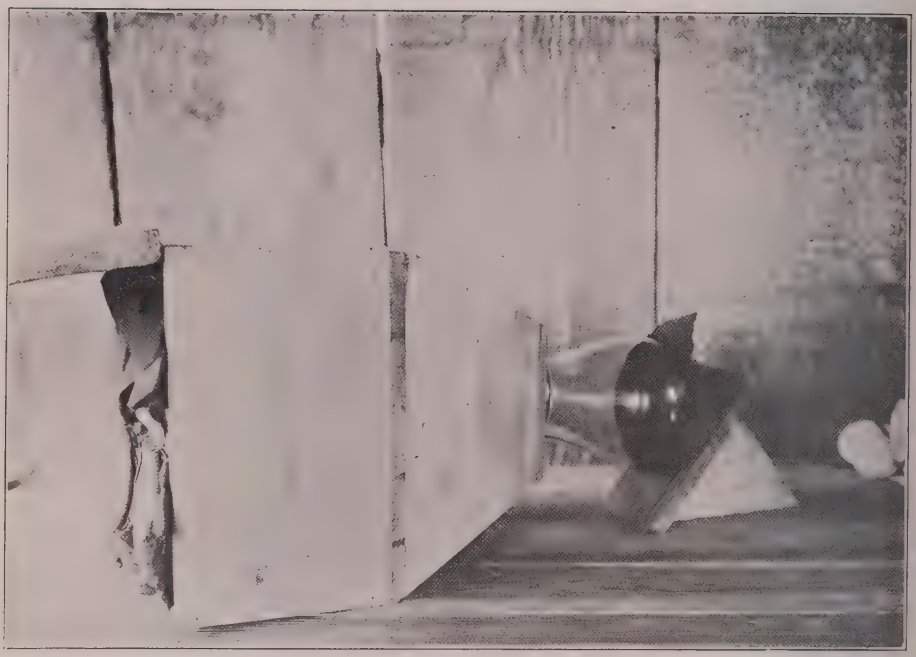


Fig. 9.

BOX USED FOR CONCENTRATING PARASITES FROM SEVERAL CHIMNEYS INTO ONE.

To left is shown door to box, opened to show chimneys of parasites within. Into this box the chimneys containing parasites are placed. The cloth covers are then removed from the chimneys and the door of the box closed. The parasites then immediately fly and crawl out of the chimneys towards the light and into the single chimney attached at the right. In this manner the parasites are soon concentrated into one container. Some grass or leaves should be kept in the concentrating chimney. This provides a natural resting place for the parasites, supplies them with some moisture and keeps them from piling over each other in a mass at the bottom of the chimney. They should not be allowed to remain concentrated for many hours, but should be liberated in the cane fields as soon as possible.

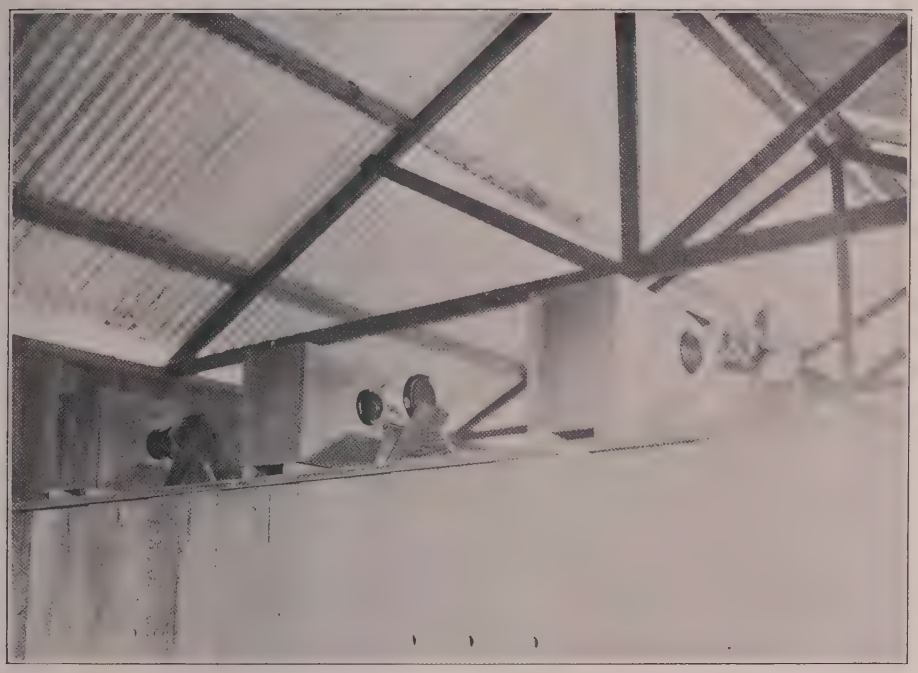


Fig. 10.

SHOWING THE CONCENTRATION BOXES IN OPERATION.

Each box contains 4 chimneys of parasites. In this case the parasites from 12 chimneys will soon be concentrated into three.

Deterioration of Cane After Cutting.

Manager F. A. Anderson of Paauhau has sent us data relative to two tests recently conducted on his plantation on the deterioration of Yellow Caledonia cane after cutting.

The work was conducted at the Paauhau Mill by Mr. Westly, the chemist. In these tests three to four sticks of cane only were used in each sample. This made it very hard to get concordant checks, but the results are very valuable and go to confirm those previously obtained by us in Honolulu.

A brief summary of the results is given as follows:

LOSS IN WEIGHT IN PER CENT.

Days after cutting..	1	2	3	4	5	6	7	8	9
First test	1.9	3.3	4.7	6.2	5.0	5.9	7.9	10.1	11.4
Second test	2.7	3.9	4.0	4.6	6.7	5.7	7.4	7.1	8.7
Average	2.3	3.6	4.3	5.4	5.8	5.8	7.6	8.6	10.0

LOSS OF SUGAR—IN PER CENT ORIGINAL SUGAR.

Days after cutting....	1	2	3	4	5	6	7	8	9	10
First test	..	5.6	19.2	20.6	26.8	33.9	32.6	29.9	30.9	...
Second test	2.4	3.2	6.8	10.5	10.8	15.7	29.0	7.8*	21.5	30.5
Average.....	2.4	4.4	13.0	15.5	18.8	24.8	30.8	29.9	26.2	30.5

* Discarded.

The details of the Paauhau tests as reported by the plantation are given as follows:

TEST I.

To determine the loss in sugar due to delays in milling cane after same is cut, 30 sticks of cane (Yellow Caledonia from Shimbori's place) was divided into 10 samples. One sample was ground the day the cane was cut. From then on, one sample was ground every day. The weight of the samples was also taken from day to day. Cane was cut on July 22, 1919.

No. of Sample.....	WEIGHT (LBS.), JULY										% Loss in Weight, Each Sample	Date Ground, July	JUICE				Sugar per Original 100 Cane	Discarding the first analysis, and using 6.44 as average Q.R. of all samples when cut, we get the following losses in Sugar:		
	22	23	24	25	26	27	28	29	30	31			Brix.	Pol.	Pur.	Q.R.		Days Old	Per 100 Original Cane	%
1	17½										...	22	21.7	18.78	86.54	7.11	14.065	..	....	....
2	14¾	14¾									...	23	21.80	20.07	92.06	6.44	15.527	1	....	....
3	18	17¾	17¾								1.38	24	22.30	19.75	88.56	6.68	14.763	2	0.864	5.565
4	15¾	15¼	15¼	15							4.76	25	22.00	18.05	82.05	7.59	12.548	3	2.979	19.186
5	16¼	16	15½	15½	15¼						6.15	26	22.60	18.19	80.49	7.61	12.332	4	3.195	20.577
6	16¾	16¼	16	16	15¾	16					4.48	27	22.50	17.06	75.82	8.40	11.371	5	4.156	26.766
7	12½	12¼	12¼	12	11¾	12	12				4.00	28	22.70	16.02	70.57	9.36	10.256	6	5.271	33.947
8	16¼	16	15¾	15¾	15½	15½	15½	15¼			6.15	29	22.70	16.44	72.42	8.97	10.463	7	5.064	32.614
9	17	16¾	16½	16	15¾	16	15¾	15½	15¼		10.29	30	23.30	17.50	75.06	8.24	10.887	8	4.640	29.883
10	17½	17	16¾	16½	16¼	16½	16¼	16	15¾	15½	11.43	31	23.10	17.42	75.41	8.25	10.736	9	4.791	30.856
Av. % Loss in Weight	1.93	3.27	4 68	6.23	5.00	5.93	7.88	10.15	11.43											

REMARKS:— The analysis of the first sample looks like something was wrong. A check made on the analysis gave the same results. The sticks for all the samples came from a train at the scale. There is a possibility that the first sample contained one or more sticks of old cane picked up from the track and thrown onto the train. It seems also logical to assume that the original Quality Ratios of the different samples have varied to some extent when cut. Another test will be conducted.

Light showers of rain between July 26th and 28th.

TEST II.

YELLOW CALEDONIA CANE FROM FIELD NO. 11, CUT ON AUGUST 4, 1919.

40 sticks divided into 10 samples. Each sample divided into two by cutting each stick in two. Each sample contained two top and two bottom parts of the four sticks. One-half of all the original samples were ground and the juice analyzed the day the cane was cut.

No. of Sample	Date Ground, Aug.	ANALYSIS WHEN CUT					Weight When Cut, Lbs.	Date Ground, Aug.	Weight When Ground	% Loss in Weight	ANALYSIS WHEN GROUND					Loss in Sugar	% Loss in Sugar
		Brix	Pol.	Purity	Quality Ratio	Sugar per 100 Cane					Brix	Pol.	Purity	Quality Ratio	Sugar per Original 100 Cane		
1	4	20.60	18.51	89.85	7.073	14.138	18	5	18	....	20.5	18.18	88.68	7.245	13.803	0.335	2.369
2	4	21.20	19.10	90.09	6.846	14.607	18½	6	18	2.700	21.5	19.12	88.93	6.880	14.142	0.465	3.183
3	4	21.00	19.15	91.19	6.789	14.730	19¼	7	18½	3.896	21.8	18.98	87.06	7.002	13.725	1.005	6.823
4	4	20.50	18.47	90.10	7.078	14.128	18¾	8	18	4.000	21.9	18.02	82.28	7.590	12.648	1.480	10.476
5	4	20.90	18.91	90.48	6.901	14.491	16¼	9	15½	4.615	22.5	18.53	82.35	7.378	12.928	1.563	10.786
6	4	20.70	18.56	89.66	7.060	14.164	18½	10	17¼	6.757	22.2	17.78	80.09	7.806	11.945	2.219	15.666
7	4	21.10	19.17	90.85	6.794	14.719	17½	11	16½	5.714	21.9	16.15	73.74	9.025	10.447	4.272	29.024
8	4	20.50	18.06	88.10	7.316	13.669	17	12	15¾	7.353	22.1	17.90	80.99	7.707	12.599	1.070	7.828
9	4	21.20	19.24	90.75	6.773	14.764	17½	13	16¼	7.143	21.8	17.37	79.68	8.014	11.587	3.177	21.519
10	4	21.30	19.45	91.31	6.681	14.968	14¼	14	13	8.772	22.5	16.72	74.31	8.676	10.400	4.528	30.518

REMARKS:—The comparatively small loss in Sample No. 8 is hard to explain. This sample had the lowest Brix, Polarization, and Purity of all the original samples. It may be that the cane in this sample was not ripe at the time of cutting and that sugar kept on forming for a day or two after cutting, and that it did not start to go back before the second or third day. There is no doubt that the riper the cane when cut, the faster it will deteriorate. The conclusion may be drawn that in the beginning of the season, when less ripe cane is harvested, deterioration is much slower. In fact, the cane may at that time be benefited by being a day or two old before it is ground. Another interesting fact is brought out—that cane from the same field and within a very restricted area will differ considerably as to sugar content and purity. The above cane was all cut within a circle of 15 feet diameter.

The rainfall during the trial was as follows: August 4, 0.01 inch; August 5, 0.01 inch; August 6, 0.01 inch; August 7, 0.27 inch; August 8, 0.05 inch; August 9, none; August 10, 0.06 inch; August 11, 12, 13, none; August 14, 0.04 inch.

Samples were kept under field conditions.

J. A. V.

Different Forms of Nitrogen.

HILO SUGAR CO. EXPERIMENT NO. 7, 1919 CROP.

This was an experiment comparing the relative value of equal amounts of nitrogen from nitrate of soda, ammonium sulfate and mixed fertilizer (B5 = 11% nitrogen and 8% phosphoric acid) in the rainy district of Hawaii. There were ten repetitions of each treatment. The fertilizations were in four equal doses as follows:

FERTILIZER—POUNDS PER ACRE.

Plots	Kind of Fertilizer	Fertilizer—Pounds per Acre.					Total P_2O_5
		Sept., 1917	Nov., 1917	Apr., 1918	May, 1918	Total Nitrogen	
A	Nit. Soda	284	284	284	284	176 lbs.	0
B	Ammo. Sulf.	220	220	220	220	176 lbs.	0
C	Mixed Fert. (B5)	400	400	400	400	176 lbs.	128 lbs.

The crop was Yellow Caledonia, second ratoons. The previous crop was harvested in June, 1917. The ranifall during the period of this crop as reported from Hilo was as follows:

July, 1917, to June, 1918, inclusive, 142 inches; 3 inches above normal.
July, 1918, to June, 1919, inclusive, 122 inches; 17 inches less than normal.

The yields for each treatment are given in the following table:

No. of Plots	Treatment	Tons per Acre		
		Cane	Q. R.	Sugar
10	Nitrate of Soda	60.8	7.29	8.35
10	Ammonium Sulfate	56.9	7.26	7.83
10	Mixed Fert. (B5)	57.2	7.19	7.95

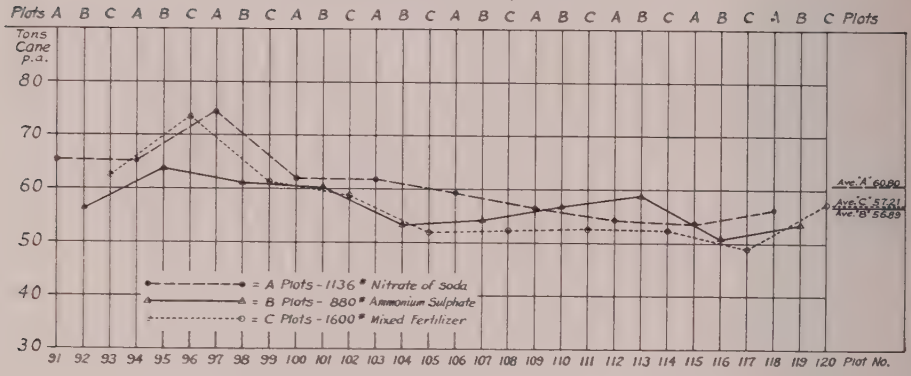
These returns indicate a gain of about half a ton of sugar in favor of the nitrate of soda. A study of the plot yields shows the nitrate of soda plots to be ahead of the adjoining plots in eight cases out of ten. This adds to the value of the results and, for the conditions of this experiment, shows nitrate of soda to be the best form of nitrogen to apply.

DETAILS OF EXPERIMENT.

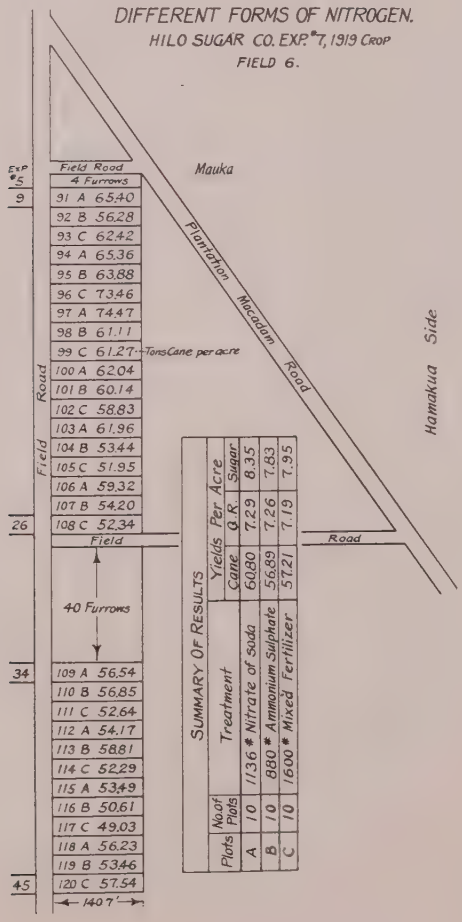
Object.

To compare: 1. Nitrate of soda; 2. Sulfate of ammonia; 3. Mixed fertilizer.

DIFFERENT FORMS OF NITROGEN.
YIELDS BY PLOTS.
HILO SUGAR CO. EXP.*7, 1919 CROP



DIFFERENT FORMS OF NITROGEN.
HILO SUGAR CO. EXP.*7, 1919 CROP
FIELD 6.



SUMMARY OF RESULTS

Plots	No. of Plots	Treatment	Yields Per Acre Cane	Q.R.	Sugar
A	10	1136 # Nitrate of soda	60.80	7.29	8.35
B	10	880 # Ammonium Sulphate	56.89	7.26	7.83
C	10	1600 # Mixed Fertilizer	57.21	7.19	7.95

Location.

Hilo Sugar Co., Field 6; plots 90 to 120, inclusive, adjoining Experiment No. 5, on the Hamakua side of field trail, which is 3½ feet wide.

Crop.

Yellow Caledonia, second ratoons.

Layout.

No. of plots—30. Area of plots—1/10 acre, consisting of 6 furrows, 5.16′ wide and 140.7′ long.

Fertilization.

All plots to receive a total of 176 lbs. of nitrogen in four equal doses: September, 1917; November, 1917; April, 1918; May 15, 1918.

Plan.

Plots	No. of Plots	Fertilizer	Pounds per Acre		Total Nitrogen
			Total	Per Appl.	
A	10	Nitrate of Soda	1136	284	176
B	10	Sulfate of Ammonia	880	220	176
C	10	Mixed Fertilizer (B-5)	1600	400	176

Nitrate of soda = 15.5% N.
Sulfate of ammonia = 20% N.
Mixed fertilizer (B-5) = 11% N. (5% nit., 5% sulf., 1% organic), 8% P_2O_5 (5% bone meal, 3% superphosphate).

Progress.

June, 1917—Previous experiment harvested.
July, 1917—New experiment planned by L. D. Larsen.
August, 1917—Experiment staked by W. P. Alexander.
September, 1917—Experiment fertilized by H. E. Starrat.
November, 1917—Experiment fertilized by R. S. Thurston.
April, 1918—Experiment fertilized by Y. Kutsunai.
May, 1918—Experiment fertilized by J. T. Moir, Jr.
July 25-29, 1918—Experiment harvested by R. Pahau.

J. A. V.

Forms of Nitrogen.

WAIPIO EXPERIMENT D (1919 CROP).*

This test consisted of: first, a comparison of equal amounts of nitrogen from soluble minerals and from organic sources; second, a comparison of nitrogen alone with the same amount of nitrogen supplemented with phosphoric acid and potash. There were 14 or 15 repetitions of each treatment. The fertilizer was applied in two equal doses in August and October, 1918. The cane was H 109, planted May, 1918, and harvested July, 1919, being 13½ months old when cut.

The fertilization and the results of the harvest are given as follows:

Plots	Treatment—Pounds per Acre	Yield per Acre		
		Cane	Q. R.	Sugar
A	900 lbs. Ammonium Sulfate	63.6	8.24	7.72
B	450 lbs. Ammonium Sulfate 580 lbs. Nitrate Soda 316 lbs. Acid Phosphate 83 lbs. Sulfate Potash	64.3	8.41	7.64
C	1000 lbs. (½ Ammon. Sul., ½ Nit. Soda)	61.9	8.26	7.49
D	1160 lbs. Nitrate Soda	63.4	8.51	7.45
E	1440 lbs. Dried Blood	57.5	8.84	6.50

We obtained very little difference in yield between ammonium sulfate and nitrate of soda. The yields of cane were identical from the sulfate and nitrate plots.

The C plots—that is, the plots receiving a mixture of equal quantities of nitrate of soda and ammonium sulfate, did not receive as much nitrogen as did the other plots. One thousand pounds of the mixture was applied on the basis of a nitrogen content of 18%. Analysis showed the mixture to contain only 16.6% nitrogen. So the C plots received only 166 pounds of nitrogen per acre as against 182 on the other plots. This should be considered in studying the results.

The dried blood was distinctly inferior, producing 7 tons of cane and 1 ton of sugar less than did either nitrate of soda or ammonium sulfate. The dried blood plots were very much slower in starting; on the other hand, it seems, as indicated by the poorer quality of the juice, that these plots did not mature as well.

The addition of phosphoric acid and potash produced no gain over nitrogen alone. This is in line with the results which we have been obtaining in Waipio Experiment V, during the last several years.

* Experiment planned by J. A. Verret.
" fertilized by R. M. Allen.
" harvested by R. M. Allen.

DETAILS OF EXPERIMENT.

Object.

1. To compare the relative value of the following forms of nitrogen: Nitrate of soda, ammonium sulfate, mixture of one-half nitrate of soda and one-half ammonium sulfate, and dried blood or other organic.

2. To compare complete fertilizer (nitrogen, phosphoric acid, and potash) with nitrogen alone.

Location.

Waipio Substation, Section 7.

Crop.

H 109, plant.

Layout.

No. of plots—72.
Size of plots—1/30 acre net.
8 lines per plot.

Plan.

FERTILIZATION—POUNDS PER ACRE.

Plots	No. of Plots	Treatment	
		August 26, 1918	October 15, 1918
A	15	580 lbs. Nit. Soda	580 lbs. Nit. Soda
B	15	450 lbs. Ammo. Sulfate	450 lbs. Ammo. Sulfate
C	14	500 lbs.: ½ Ammo. Sulfate, ½ Nit. Soda	500 lbs.: ½ Ammo. Sulfate, ½ Nit. Soda
D	14	720 lbs. Blood	720 lbs. Blood
E	14	450 lbs. Ammo. Sulfate 158 lbs. Acid Phosphate 41 lbs. Sulfate Potash	580 lbs. Nit. Soda 158 lbs. Acid Phosphate 41 lbs. Sulfate Potash
Crop....	.....	450 lbs. Sulfate Ammonium	580 lbs. Nitrate of Soda

Progress.

May 20, 1918—Experiment planted.
August 7, 1918—Experiment fertilized.
October 23, 1918—Experiment fertilized.
July, 1919—Experiment harvested.

J. A. V.

Second Season Fertilization.

ONOMEA EXPERIMENT NO. 3 (1919 CROP).*

This was an experiment testing the economic limit to second season fertilization. During the first season all plots received a uniform application of fertilizer consisting of 200 pounds of nitrate of soda per acre during October, 1917, and 500 pounds of mixed fertilizer on November 29, 1917. Before planting, four years ago, this field received a heavy dressing of manure and mud press cake.

The cane involved in this test was Yellow Caledonia, first ratoons.

The second season fertilization and the yields obtained are given in the following table:

Plots	Treatment—Pounds per Acre			Yield per Acre		
	April 15, 1918	May 25, 1918	Aug. 7, 1918	Cane	Q. R.	Sugar
A	0	0	0	58.8	7.51	7.83
X	300 lbs. N. S.	0	0	58.7	7.54	7.78
B	300 lbs. N. S.	300 lbs. N. S.	0	58.8	7.33	8.03
C	300 lbs. N. S.	300 lbs. N. S.	300 lbs. N. S.	57.7	7.91	7.29

In this experiment the fertilizer applied during the second season was of no benefit whatever. The results from this experiment this year are in striking contrast to those obtained two years ago with similar treatments. In 1917 gains of from a little over half a ton of sugar to three-quarters of a ton were obtained with the increased amounts of fertilizer. (See *Planters' Record,* Vol. XVII, page 170.)

DETAILS OF EXPERIMENT.

Object.

To find the economic limit to second season fertilization. (This is a repetition of Experiment No. 3, 1917 crop.)

Location.

Onomea Sugar Co., Field 29, Papaikou Section, along the roadway from the stables, on the Hamakua side of the road.

Crop.

Yellow Caledonia, first ratoons.

Layout.

No. of plots—30. Size of each plot—1/10 acre, consisting of 6 lines, each line 5.85′ wide and 124.1′ long.

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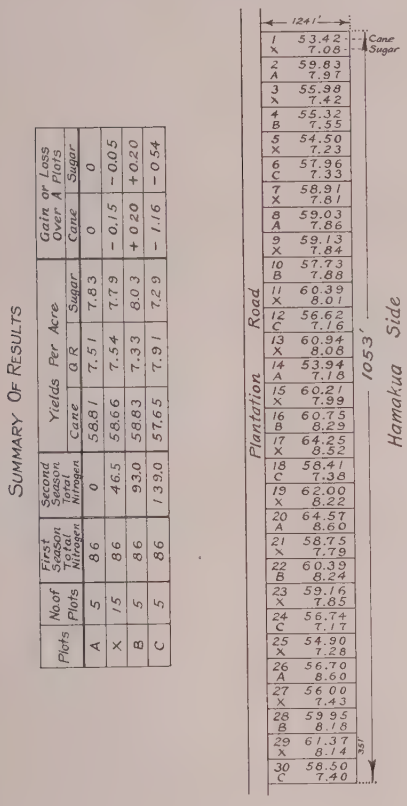
* Experiment planned by L. D. Larsen.
" laid out by L. D. Larsen and J. S. B. Pratt, Jr.
" fertilized by J. T. Moir, Jr., and Y. Kutsunai.
" harvested by W. L. S. Williams.



Fertilization.

First season, uniform to all plots by the plantation, as in the surrounding field.

Plan.

SECOND SEASON—POUNDS NITRATE OF SODA PER ACRE.

Plots	No. of Plots	Plot Nos.	Mar. 15, '18	May 15, '18	July 15, '18
A	5	2, 8, 14, 20, 26	0	0	0
X	15	Odd numbered	300	0	0
B	5	4, 10, 16, 22, 28	300	300	0
C	5	6, 12, 18, 24, 30	300	300	300

Progress.

June 12-14, 1917—Previous experiment harvested.
October 11, 1917—Experiment fertilized.
November 29, 1917—Experiment fertilized.
April 15, 1918—Experiment fertilized.
May 25, 1918—Experiment fertilized.

August 7, 1918—Experiment fertilized.

July 10-11, 1919—Experiment harvested.

The weighing was done by bundle in the field, every third bundle being weighed; deductions were made for tare according to the plantation practice.

The samples for juice tests were composited for each series of treatments. These were run through the mill and analyzed by the plantation chemist.

Onomea Experiment No. 5, 1919 Crop.*

The object of this experiment was to determine the most profitable amount of fertilizer to apply in a single dose during the second growing season. The cane was Yellow Caledonia, second ratoons.

During the first season all plots received a uniform application of 800 pounds per acre of mixed fertilizer. This was put on in two equal doses on June 18 and October 10, 1917. This fertilizer supplied 88 pounds of nitrogen and 64 pounds of phosphoric acid.

The fertilization during the second season and the results of the harvest are given as follows:

Plots	Treatment—Pounds per Acre B5 = 11% N., 8% P_2O_5	Total Lbs. Nitrogen in Two Years	Tons per Acre		
			Cane	Q. R.	Sugar
A	0	88	43.7	7.10	6.15
B	400	132	44.9	7.43	6.04
X	800	176	45.7	7.27	6.29
C	1200	220	45.7	7.05	6.48
D	1600	264	47.6	7.35	6.47

In this experiment there is but little gain from the fertilizer applied in the second season. Two years ago gains of over one and one-half tons of sugar, from the larger amounts of fertilizer, were obtained from similar treatments in this test. (*Planters' Record,* Vol. XVI, page 346.)

DETAILS OF EXPERIMENT.

Object.

To determine what is the most economical amount of mixed fertilizer (B5) to apply in one dose in the second growing season.

Location.

Onomea Sugar Co., Papaikou section, Field 35, on Hilo side of macadam road.

Crop.

Yellow Caledonia, second ratoons.

Layout.

40 plots, each 1/10 acre, consisting of 6 furrows, 5.94 ft. wide and 122.2 ft. long.

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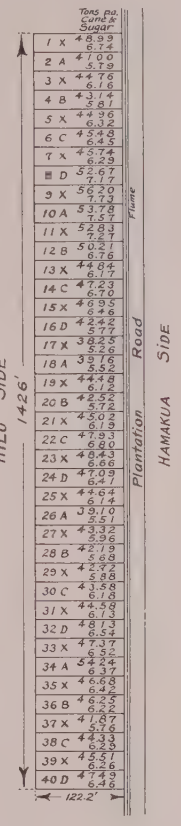
* Experiment planned by L. D. Larsen.
" laid out by J. S. B. Pratt, Jr.
" fertilized by W. P. Alexander, J. T. Moir, Jr., and Y. Kutsunai.
" harvested by R. Pahau.

AMOUNT FERTILIZER TO APPLY.
ONOMEA SUGAR CO. EXP. #5, 1919 CROP
FIELD 35.



Summary Of Results

Plots	No. of Plots	First Season Total Lbs Nitrogen	Second Season Total lbs Nitrogen	Yields Per Acre		Gain or Loss over A Plots	
				Cane	Q.R. Sugar	Cane	Sugar
A	5	88	0	43.66	7.10 6.15	0	0
B	5	88	44	44.86	7.43 6.04	+ 1.20	+ 0.11
X	20	88	88	45.70	7.27 6.29	+ 2.04	+ 0.14
C	5	88	132	45.71	7.05 6.48	+ 2.05	+ 0.33
D	5	88	176	47.56	7.35 6.47	+ 3.90	+ 0.32

Fertilization.

First season—All plots to receive uniform fertilization at the rate of 800 lbs. B5 per acre, applied in two equal doses, June 15, 1917, and October 15, 1917.

Second season—One application of B5 fertilizer, April 16, 1918, as follows:

Plots	Plot Numbers	Pounds B5 Fertilizer per Acre
A	2, 10, 18, 26, 34	0
B	4, 12, 20, 28, 36	400
X	All odd-numbered plots 1-39 inc.	800
C	6, 14, 22, 30, 38	1200
D	8, 16, 24, 32, 40	1600

B5 = 11% Nitrogen (5% nitrate, 5% sulfate, 1% organic), 8% P_2O_5 (5% bone, 3% superphosphate).

Progress.

May 15, 1917—Previous crop harvested.

June 18, 1917—400 pounds B5 per acre applied.

July 25, 1917—Experiment staked.

October 10, 1917—400 pounds B5 per acre applied.

April 16, 1918—Experiment fertilized.

June 20-21, 1919—Experiment harvested.

Cane weighed by bundle in the field; each third bundle was weighed. Tare deductions were made in accordance with plantation practice.

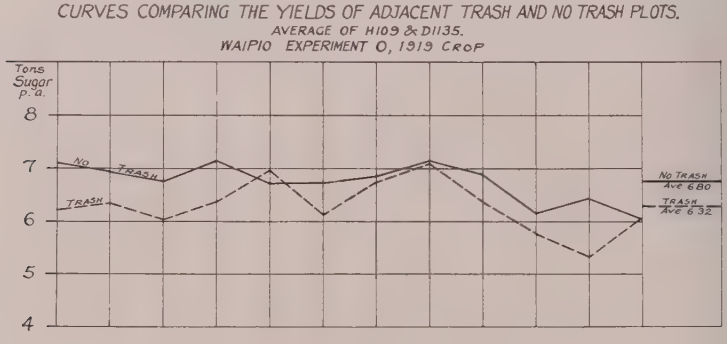
Each fifth bundle was sampled. The samples from all plots receiving similar treatments were composited. These were run through the last mill and analyzed by the plantation chemist.

J. A. V.

Trash Conservation.

Waipio Experiments H and O, 1919 Crop.*

The object of these experiments was to test the value of trash conservation when the trash is pali-pali-ed on top of the line and not buried. The cane involved was H 109, first ratoons, short, in "H"; and H 109 and D 1135, second ratoons, short, in "O."



The trash was pali-pali-ed immediately after the harvesting was finished. This trash was bundled on top of the line and not covered with dirt in any way. In the "no trash" plots the trash was removed from the plots, not burned on them. With the exception of the trash work, all the plots received identical treatment.

The results of the harvest are given in the two following tables:

* Experiments planned by J. A. Verret.
Work conducted and experiments harvested by R. M. Allen.

WAIPIO EXPERIMENT H.

Treatment	Tons per Acre		
	Cane	Q. R.	Sugar
Trash	51.8	9.90	5.25
No Trash	49.8	9.27	5.35

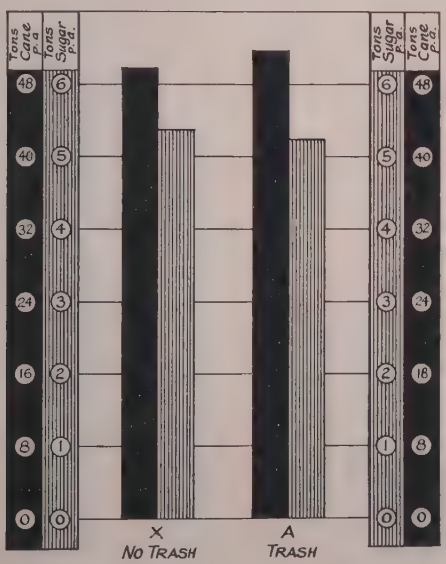
WAIPIO EXPERIMENT O.

Treatment	Variety	Tons per Acre		
		Cane	Q. R.	Sugar
Trash	H 109	54.5	8.18	6.66
No Trash	H 109	55.0	7.75	7.10
Trash	D 1135	53.4	8.94	5.97
No Trash	D 1135	54.2	8.34	6.50

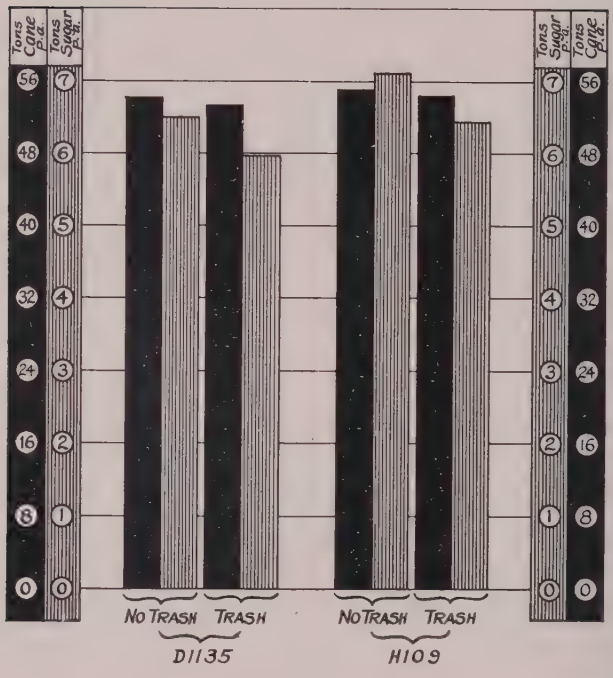
In "H" we get a gain of two tons of cane from the trash plots. But on account of poor juices these plots produced slightly less sugar than did the no-trash plots.

In "O" both the H 109 and the D 1135 produced less cane and sugar from the trash plots. The difference amounts to half a ton of sugar in favor of no trash. This difference was caused, not by any great difference in cane weights from the two treatments, but to a distinct difference in the quality of the juices.

TRASH VS. NO TRASH.
WAIPIO EXP. H, 1919 CROP



TRASH VS. NO TRASH.
WAIPIO EXP. O, 1919 CROP
SECTION 29.



In all cases the juices from the trash plots were poorer than those from the no-trash plots.

From these results it would seem that trash, when not buried, is not as valuable as had been popularly supposed, under condition such as exist at Waipio.

We plan to continue these tests, burying the trash as much as possible.

TRASH CONSERVATION—WAIPIO EXPERIMENT "H."

Object.

1. To determine the effect on the soil and yield of a continued practice of removing the trash after harvesting as compared with the effect of leaving the trash.

NOTE:—This experiment should be continued with subsequent crops so as to obtain data on the ultimate effect on soil and cane of continued trash conservation.

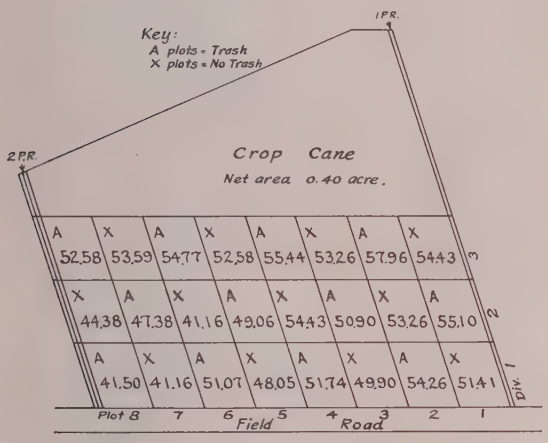
Location.

Waipio Substation, Section 15.

Layout.

No. of plots—24.
Size of each plot—1/40 acre (net).
No. of rows per plot—6.

TRASH VS. NO TRASH.
WAIPIO EXP. H, 1919 CROP
SECTION 15.



Summary Of Results

Plots	No. of Plots	Treatment	Yields Per Acre		
			Cane	Q.R.	Sugar
X	12	No Trash	49.79	9.27	5.35
A	12	Trash	51.81	9.90	5.24

Crop.

H 109, first ratoons, short.

Plan.

X plots, trash removed (not burned on plots).

A plots, trash left.

Fertilization.

Uniform.

POUNDS FERTILIZER PER ACRE.

Plots	Total Area Net, Acres	August, 1918	October, 1918	Total Nitrogen
All Plots and Crop Cane	1.02	450 lbs. Ammo. Sulp.	580 lbs. Nit. Soda	182

WAIPIO EXPERIMENT "O"—TRASH CONSERVATION.

Object.

To determine the effect of conserving trash on ratoons of D 1135 and H 109.

Location.

Waipio Substation, Section 29.

Plan.

No. of plots—24.

Size of plots—1/15 acre (net).

No. of rows per plot—16.

TRASH VS. NO TRASH.

WAIPIO EXPERIMENT O, 1919 CROP

Section 29.

D1135	H109	D1135	H109	D1135	H109	
D 54.18	X 49.64	D 53.42	X 49.14	D 50.65	X 40.82	8
X 52.04	D 51.79	X 47.25	D 51.91	X 49.52	D 49.90	7
		Str. Ditch				
C 56.20	X 52.79	C 56.07	X 55.19	C 57.96	X 63.63	6
X 56.57	C 59.09	X 55.06	C 61.61	X 54.68	C 55.94	5
B 53.68	X 51.41	B 53.30	X 55.44	B 56.32	X 63.25	4
X 53.68	B 54.81	X 52.16	B 57.08	X 57.46	B 57.83	3
A 51.66	X 51.41	A 52.54	X 56.32	A 51.91	X 56.83	2
X 56.86	A 55.06	X 53.17	A 53.42	X 54.68	A 59.60	1
2 P.R.						Div. 1
Plot 6	5	4 Field	3 Road	2	1	1 P.R.

Summary of Results

Variety of Cane	Treatment	Yields Per Acre		
		Cane	Q.R.	Sugar
D1135	No Trash	54.23	8.34	6.50
D1135	Trash	53.35	8.94	5.97
H109	No Trash	55.01	7.75	7.10
H109	Trash	54.48	8.18	6.66

Trash removed (not burned) from following plots:

(1.1—1.2)	(1.5—1.6)	(2.3—2.4)	(3.1—3.2)
(3.5—3.6)	(4.3—4.4)	(5.1—5.2)	(5.5—5.6)
(6.3—6.4)	(7.1—7.2)	(7.5—7.6)	(8.3—8.4)

Trash left on following plots:

(1.3—1.4)	(2.1—2.2)	(2.5—2.6)	(3.3—3.4)
(4.1—4.2)	(4.5—4.6)	(5.3—5.4)	(6.1—6.2)
(6.5—6.6)	(7.3—7.4)	(8.1—8.2)	(8.5—8.6)

Fertilization.

Uniform, as follows: May 30, 1918, 450 lbs. ammonium sulfate; August 15, 1918, 580 lbs. nitrate of soda.

J. A. V.

Steam Sterilization of Soil Increases Germination.

That sterilization of the soil with steam will increase the germination of sugar cane seed was demonstrated recently by a test at Oahu Sugar Company. The effect on the subsequent growth is yet to be determined.

Four and one-half lines of cane having "Lahaina disease" were dug up, and the soil pulverized to a depth of 12 inches. Two lines of the area were left unsteamed to serve as a check. The steaming progress was accomplished on the remaining two and one-half lines as follows:

A shallow redwood box enclosing an area of about 28 square feet was constructed, having the edges bound with a sharpened piece of iron. This box was inverted over the portion of the soil to be steam-treated, and moved at fifteen-minute intervals. A hose connection was made at one side, and the box filled with live steam, brought from the exhaust valve of a locomotive stationed on a nearby track. With a pressure at the locomotive of 100 lbs., during each period of 15 minutes, the steam completely penetrated the soil to a depth of 6 inches, potatoes being well cooked when buried at this depth. Readings of the thermometer gave the following temperatures:

Pressure, 100 lbs. Steaming, 15 minutes. Depth, 6 inches. Temperature, 212 F.

Pressure, 100 lbs. Steaming, 15 minutes. Depth, 8 inches. Temperature, 175 F.

The heat penetrated to about 10 inches, and the soil was warm to a depth of 12 inches where the soil was not too hard.

The lines were steamed on June 30, and on July 1 both steamed and unsteamed areas were planted with Lahaina cane. Seed was obtained from one-year-old cane, and care was taken to have the planting uniform in all lines. Germination in the steamed lines started first, and three weeks after planting the difference between the steamed and unsteamed lines was strikingly in favor of the former. (See Figs. 1 and 2.) Actual count of green shoots gave:

RESULTS OF STEAM STERILIZATION.

Fig. 1.

The result of sterilization of soil with live steam is shown in the two lines of young cane on the left of the picture. The untreated lines, on the right, have only a few shoots which have come up. Photo taken 22 days after planting.

Fig. 2.

Another view of steam sterilization test taken at the same time as Fig. 1. Only a very few shoots appear in the "no steam" lines (to the right). In the background is seen diseased Lahaina cane. Stools of similar cane having root-rot were dug up from area used for experiment.

Steamed lines	222 shoots
Unsteamed lines	55 shoots
Gain for steaming	167 shoots

Two weeks later the difference in stand was less noticeable, but the growth of cane in the steamed lines was ahead of that in the unsteamed lines.

Since the cane had probably not become dependent upon its root system for plant food, we cannot yet credit steam sterilization with acting as a controlling measure of the root-rot disease. It was purely a gain in germination which was caused by the steaming of the soil.

Russel* shows that bacterial growth is increased by partial sterilization, and decomposition of some of the soil constituents is caused by the steam quite apart from its effect on the soil flora. The new flora arising after partial sterilization is found to be more active than the original flora in effecting the decomposition of nitrogenous matter, such as peptone, and in hydrolyzing urea.

The experiment is being carried on to determine the effect of steam sterilization of the soil on the final growth of the cane. W. P. A.

Mottling Disease or Mosaic of Sugar Cane.†

By C. W. Edgerton.**

The disease of sugar cane which has received the most attention and has been the most discussed during the past few years is the one known as the Mottling Disease or Mosaic. During this period this disease made its appearance in Porto Rico and spread rapidly through some sections of the island. From the reports that have been published, the trouble is evidently causing a large loss and is threatening the industry in that country. This disease, or a very similar one known as the Yellow Stripe, is present in many tropical sugar regions, but, from the literature on the subject, it is evident that the losses caused are far greater in Porto Rico than in other places. Whether there are two troubles or whether there is only one with a different effect in different places is not definitely known at present. The situation in Porto Rico as summarized by J. A. Stevenson, formerly pathologist of the Porto Rico Experiment Station, is as follows:

"The loss to date is believed to have reached half a million dollars, the damage resulting from stunting of the plants, reduction in amount of the juice, and final death of the stools. In addition, such juice as is obtained is very difficult to handle in the mill. The symptoms are first a peculiar mottling of the leaves; pearly white linear spots and lines on a normal green background, or in early

* "Soil Conditions and Plant Growth," pp. 130-133.

† The Louisiana Planter, June 21, 1919, p. 397.

** Plant Pathologist, Louisiana Agricultural Experiment Station.

stages yellow-green lines and blotches. In more advanced cases cankers appear on the stalks, long linear, brown to gray in color and sunken."

That this disease might be present in Louisiana was not suspected until we received reports that some Louisiana cane planted in Porto Rico developed the disease. This cane came originally from Audubon Park, but was sent by officials from the United States Department of Agriculture for experimental purposes. As the young plants developed, they showed a high percentage of the disease. As the disease is supposed to be carried through the seed canes and not through the soil, this was good evidence that the disease was on the cane shipped from New Orleans.

With this information, it seems evident that we have either had the disease in this country for some time, possibly doing but little damage and not being recognized as the same as the Porto Rican trouble, or else that it has but recently gained entrance to this country and has hitherto been overlooked. The former is probably the correct explanation. We have a mottling disease in this country, and have had for some time, and, while we have never associated it with the mottling disease of Porto Rico or with the Yellow Stripe of other tropical countries, it is more than likely that it is the same. In some of the Louisiana fields it is often difficult to find a stalk that would be classed as healthy. However, under our conditions, the cane seems to grow fairly well and produces the normal amount of sugar. Whether the cane would produce more if the disease were not present is another question and one upon which we have no information. This opens a wide field of investigation, however, and we expect to start some work to determine what effect the disease is having upon the Louisiana sugar industry. It may be that we shall find that the disease is doing more damage than we realize. It may also be found that this trouble is partly responsible for the deterioration of some of our varieties during the past few years in some sections of the State D 95, particularly, has shown marked deterioration in some places. This has been attributed to the Root Rot disease, but it is possible that the Mottling Disease has also had its effect.

A recent article by Mr. C. O. Townsend of the United States Department of Agriculture has made it seem more evident to us that the Porto Rican disease is the same that we have here. He states that Kavangera cane, one of the Japanese varieties, is immune to the disease. All the Japanese canes in Louisiana also seem to be immune. The darker green color of the Japanese canes is a condition which has been noted for some time in some sections of the State, and this condition is due to the fact that the Mottling Disease is not present.

A recent examination of the canes at Audubon Park has shown that all the canes which are being grown for sugar are susceptible to the disease. It was noted, however, that the L 511 cane had a smaller percentage of diseased stalks than some of the other varieties. Whether this is due to natural resistance or whether it has not been grown long enough to become completely infected is not known. It is also interesting to note that cane which was received from Georgia showed as high a percentage of the disease as the cane grown in Louisiana. It is evident that this disease may be found in various parts of this country.

This disease is not present in all Louisiana fields at present. I have seen some fields in which a careful examination showed no trace of it.

[H. P. A.]

Hauling Cane by Motor Truck in Cuba.

It is reported that the ox-cart so universally employed in Cuba for hauling cane is apt to be replaced to a large extent by a motor truck with removable load-

A motor truck which promises to replace the Cuban bull-carts in hauling cane. The truck operates with removable bodies, leaving one to be loaded with cane, while the second with a full load is transported.

This view shows the process of picking up a loaded body. This the truck does by its own power. Note the drum by the driver's seat, and the cable which draws the body into position.

ing bodies, especially designed for the purpose. According to a correspondent, who furnishes the accompanying photographs,

"A bed is dropped in the field by the truck and it (the truck) proceeds to take up on to itself another bed which is already loaded with cane. This it does by simply attaching two cables to the lower part of the bed. These cables are attached to drums or nigger heads at the front of the machine, and when the cable is wound up, the bed is pulled aboard and, after being fastened by two clamps, the truck proceeds to a loading station where the load is taken off and the truck returns to the field with empty bed, which it unloads and goes to a full bed and the same process continues. This truck has done the work of four bull-carts at less than one-third the cost and working at only one-half of its possibility, as the truck may be operated night and day whereas the bull-cart may work only eleven to thirteen hours per day. In other words, if worked to full capacity, the truck will do the work of seven to eight carts at one-third or less of the cost."

[H. P. A.]

Growing Seedlings in Louisiana.

The difficulties of propagating seedling canes under temperate zone conditions are dealt with in a recent paper from the Louisiana Sugar Experiment Station by W. G. Taggart, published in the "Louisiana Planter" of July 12, 1919.

The Louisiana canes, under their restricted growing season, do not develop tassels, and hence all the material for obtaining germinations must be imported from abroad. Delays and fumigation incident to federal quarantines further handicap the procedure. These difficulties, coupled with the necessity of propagating the new canes in greenhouses with artificial heating, have limited the number of Louisiana seedlings to date to less than two thousand in all.

Notwithstanding, they have secured a few new varieties that give commercial promise, and we read with interest that one of these has gained prominence by virtue of the high sugar content that it attains under the short growing season that so severely handicaps all varieties under Louisiana conditions.

"By far the most attractive variety of sugar cane that we have ever had at this Station is Louisiana 511, another seedling from D 74, and we might say a twin sister to L 231, L 218, L 219 and L 226, since they all came from the same lot of seed. This variety, with the exception of last year, has led all competitors in richness of juice since it first came into prominence in 1909. The lowest sucrose content that it has shown was 10.9 per cent in 1910, when, under very favorable growing conditions, a selected row produced 33 tons per acre. The richest in sucrose that it has shown at the Station was 17.4 per cent in 1916. The average per cent sucrose for all the years from 1909 through 1918 is 13.52. It is remarkable to note that this variety has invariably shown a sucrose content of from two to four and nine-tenths more than the standard cane D 74, when grown under the same conditions and tested at the same time. It is unfortunate that we have not been able to get more information indicating what tonnage we can expect to get from this cane. Since the planters got interested in it we have been able to keep but a few rows and often just part of a row to weigh up. In shipping cane for

seed we make it a practice to ship only borer-free stalks, and in order to get enough to supply the demand, it has been necessary to sacrifice data on tonnage during most of the year. Such figures as we have been able to secure on this point would lead us to believe that the cane will hardly produce as much tonnage as D 74 or Purple. On the other hand, we feel sure that this difference in sucrose will more than make up in sugar in the bag for any loss in weight of cane per acre."

In one instance this new variety shows a sucrose content of 19.94 in the juice, which is very exceptional under the conditions in question.

With a total production of 955 seedling canes prior to 1911, Mr. Taggart reviews the subsequent work. Some twenty canes of the earlier propagations are still retained as hopeful possibilities.

"To briefly summarize this work, done since the 1911 report, we have received and planted 164 lots of cane seed from the gentlemen who have been named. We are deeply grateful to them for their valuable assistance and especially to those who, year after year, have furnished us with seed. From all the plantings we have succeeded in getting 887 varieties of cane into the field. As in all other such work, many of these seedlings were proven to be worthless and have been discarded. Of the 887 varieties secured, we still have 247 that have stood the test so far. Many of these are of mediocre value, but some of them are very promising and within the next few years may be ready for distribution. One cane of this lot, L 974, enjoys the distinction of being the only variety since 1909 to yield a juice that was richer in sucrose than that from L 511. Last fall plant cane from L 974 gave a juice that contained 14.05 per cent sucrose, whereas plant cane of L 511 only tested 13.86 per cent sucrose in juice. It is notable that L 551 stubble about the same time ran 15.29."

[H. P. A.]

A Scarifying Machine.

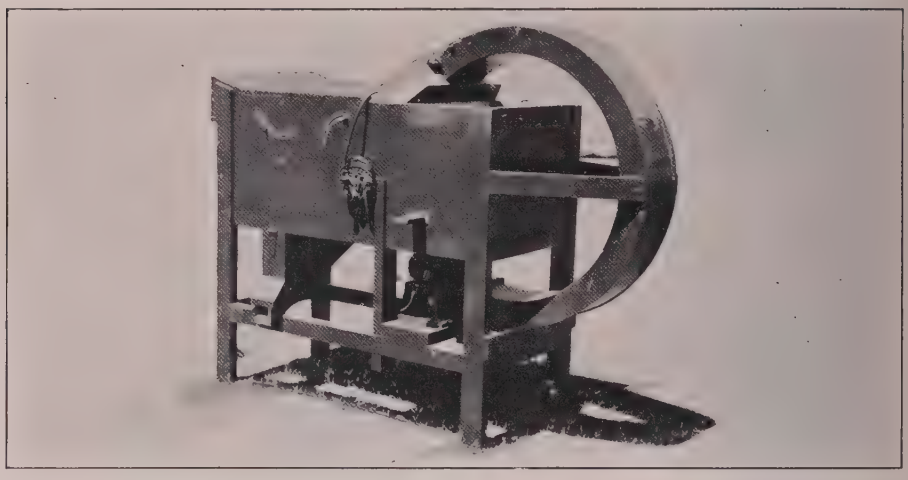


Fig. 1.

The above photograph (Fig. 1) illustrates a scarifying machine built at the Station from modified specifications obtained by Mr. A. Gartley of C. Brewer & Co. from the Iowa State College.

Many legumes have a large percentage of "hard" seed with seed coats impervious to moisture, so that the seeds cannot germinate and grow. The object of the above machine is to so scratch the surface of the seeds that germination will be nearly perfect, the seeds being able to absorb moisture and sprout.

The seeds are delivered into the fan casing (underneath the machine) by the chute, and are struck sharply and forcibly by the fan blades, and are then conveyed by such impact, and also by the strong air blast caused by the fan, into the semicircular spout. The spout is lined with a coarse sandpaper, and the seeds, in passing through, over this rough surface, have their hard, impervious seed coats scratched, punctured, cracked, or otherwise softened, making it possible for the seed to take in dampness.

The machine has been tried out successfully, using the wild crotalaria seed, or rattle pod (*Crotalaria saltiana*). It is a native legume growing as a weed on many of the plantations. When sown as a cover crop it is very difficult to obtain a stand owing to poor germination of the seed.

A germination test was started in duplicate, using an even hundred seeds in each pot. The accompanying photograph (Fig. 2) shows the decided gain for the scarifying process. After twenty days we find the following counts of germination, which are taken as per cents based on the 100 original seeds:

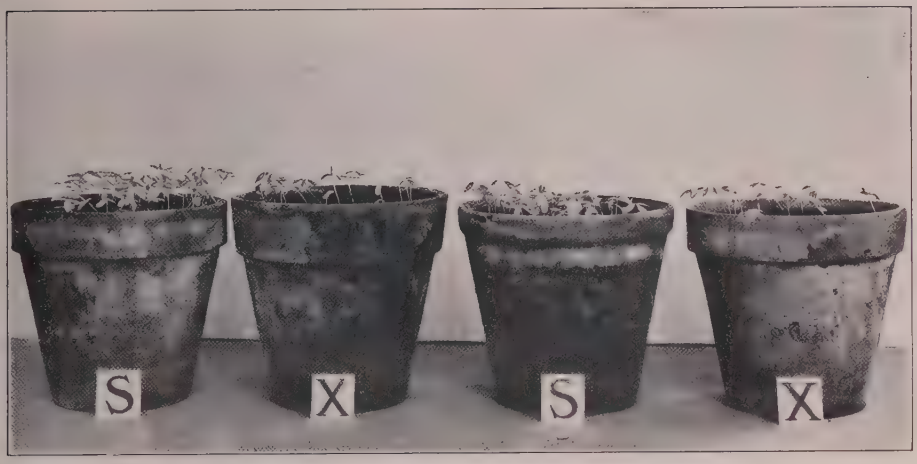


Fig. 2.

A germination test, showing the effect of scarifying seeds of wild crotalaria, gain in germination of "S" over "X" plots being about 50 seeds.

X pots, no scarifying	16%	17%
S pots, scarified by running through machine five times...	67%	65%
Gain, scarifying over no scarifying	51%	48%

These results demonstrate the practicability of using the machine on a large scale by the plantations to obtain seed of crotalaria, which will give good germinations for a green manuring crop. W. P. A.

American Cane Growers' Association in Sugar Cane Extension Work.*

The American Cane Growers' Association, realizing the good accomplished and improvements made in many different lines of scientific agriculture, by the State Extension Department has realized also the need of this work in the sugar industry of Louisiana. While the problems of the Cane Growers' Association, heretofore, have been mainly along legislative lines in safeguarding the vital interests of the Louisiana sugar manufacturers, the organization has always been ready to work on any problem or to cooperate with any movement that is to the interest and to the welfare of the sugar planters. For this reason the

* Louisiana Planter, July 12, 1919. A paper by C. B. Gouax, Assistant Emergency District Agent, Baton Rouge, La., read at the Louisiana Sugar Planters' Field Day, Audubon Park, July 10, 1919.

Association is now cooperating with the Extension Department in employing a representative to cover the sugar parishes and to work with the planters on their particular problems in agriculture. These pertain to better methods of cultivation, better usage of fertilizers, the improvement and building up of soils, the testing of various varieties of cane, the selection of seed cane, the control of insect and fungus diseases, and the study of irrigation and tractor problems. In particular it has to do with bringing to the attention of planters new methods or modifications used in other parishes, or by neighboring planters which have proved better than the old methods.

I realize and appreciate fully that the Louisiana planters as individuals possess both learning and experience in their business, and they have shown their ability by staying in an enterprise which has offered such innumerable difficulties that have threatened the very life of the Louisiana sugar industry. We do not profess to know all about your problems, but we want to know exactly what they are, so that with your assistance and with the cooperation of specialists employed for the purpose, these problems can be thrashed out. In conducting work of this kind, experimental work has to be resorted to for the most part, in order to try out and prove the merits of the new methods proposed. The success of each experiment will depend largely on the interest of the planter, and unless he is willing to be an interested party the experiment will be of little use. The object of fertilizer experiments, for instance, is to find out the soil requirements for sugar cane in Louisiana, and not have to rely on the results from Illinois or some other State where conditions, crops and soils are different. I am anxious to work with the planters along these lines, and will do my best to make this work a success. It is true that the sugar district is quite large, being composed of a group of twenty-three parishes, but as the work progresses with the aid of the Extension Department a sufficient force can be put on to do the required work, and give the planters the necessary attention in scientific agriculture.

When this work was inaugurated a few months ago and I was placed in charge, I found so much to do, and so little time to do it in, that I decided to spend the first month in acquainting myself at first hand with present conditions. To this end, I visited a large number of planters and talked over matters with them and their managers. It soon became evident that if we were going to accomplish anything it would be necessary to confine ourselves at the outset to two or three dominating questions, and out of the multitude of questions, all of them important, which the Louisiana planter has to answer, we decided to select three for the present. Fertilizers, Cane Varities, and Irrigation. I have thought it might be of interest to outline what we have already accomplished in these lines, not so much on account of the results obtained, which, of course, have not yet been reached at all in reality, as in order to show what kind of work we endeavor to do. For convenience, therefore, I shall divide this description into sub-heads and inasmuch as it is the middle of July, I shall make my descriptions as short as possible.

FERTILIZERS.

The cane planters as a rule are generally hard pressed for time, and in a good many cases prefer to stick to routine methods, rather than to make trials that would prove more beneficial and give better results. The rainfall this year has been unusual, and the labor situation has been very trying, making it difficult for the planters even to keep their fields clean and partly cultivated. In a good many cases where it has been customary to apply commercial fertilizer, the practice has been discontinued this year on account of the uncertainty of conditions and the exorbitant prices of the fertilizers. Some planters have discontinued the use of fertilizer entirely, adopting the three-year rotation and turning under a portion of the cowpea crop, and are claiming that the results obtained are as good as those obtained with the application of fertilizers.

Lands that have been cultivated in cane for long periods of time, often reach the stage where both the tonnage and the quality of the cane are very unsatisfactory. In some cases the yields are fair but the quality of the juice is poor. Such a condition is caused generally by a lack of phosphoric acid in the soil, and is generally remedied by the application of a fertilizer containing this element in an available form, such as acid phosphate. The question is, does this pay? The practical application of field experiments offers a ready means of determining the plant food requirements of soils. These experiments are generally conducted with the principle elements of plant food, nitrogen, phosphorus and potassium. The trials can be easily conducted on any plantation without any difficulty, and when performed in this way the planter secures information pertaining to his particular crops and to the soils on his own plantation, and does not have to rely on results that were obtained in some other locality. In this work, a uniform field is selected with young cane of uniform stand, divided into plots or blocks, measured, staked off, and the fertilizers mixed and applied in the usual manner with the meal box. One or two plots are left unfertilized to serve as checks. At the end of the season before harvest, handmill tests are made of each plot, using samples consisting of three average stalks of cane to note the difference in sucrose content. The plots at harvest time are weighed separately and the juice analyzed again. The results of the experiments are obtained from this data.

At the Sugar Experiment Station, Mr. Taggart, the Assistant Director, for a number of years has been conducting among the many experiments, one with nitrogen and phosphoric acid, and very encouraging results have been obtained from the mixture where the phosphoric acid is in excess of the nitrogen. In this experiment dried blood and cotton seed meal are used as sources of nitrogen, and acid phosphate as the source of phosphoric acid. In one plot 25 pounds of nitrogen and 36 pounds of phosphoric acid are used, and in the other 25 pounds of nitrogen and 72 pounds of phosphoric acid. The latter is giving the best results at the park. I am now conducting this experiment on some of the plantations in the sugar district, among which are the following:

Iberville Parish—A. Wilbert & Sons, Evergreen Plantation; J. W. Supple,

Catherine Plantation; Murrell Planting & Mfg. Co., Glenmore Plantation; E. J. Clifton, Marionneaux Plantation.

Pointe Coupee Parish—Phillips Planting Co., Lakeland.

Lafayette Parish—Overton Cade, Bellevue; Eug. Landry, Youngsville; F. M. Burley, Youngsville.

St. James Parish—Colonial Sugars Company, Gramercy, David Plantation.

When the results of these plantation experiments are tabulated they will serve to confirm or to modify the results of the Sugar Experiment Station.

IRRIGATION.

Inasmuch as irrigated land in Hawaii will raise two to three times as much cane as other Hawaiian lands, which rely on natural rainfall, and inasmuch as the experience of all agricultural communities where irrigation has been practiced has been to confirm its value, and in particular as recent experiences in Porto Rico, Mauritius, South America, Mexico and other sugar countries are exactly in line with the Hawaiian experiences it has been thought necessary to call the attention of the Louisiana planters again to irrigation. Usually in a country where the rainfall is already more than is necessary, irrigation is discredited at the start and seems unnecessary to the average man, and particularly in Louisiana, where the main problem is drainage, it looks at first sight almost absurd to wish to add water to the soil when so much of our effort is spent in getting water off of the soil. It might be well, therefore, to consider conditions. Cane in Louisiana has a very short growing season. It sprouts in March and is harvested in about eight months. If it is to mature in this season it can't waste any time, for sugar cane in the tropics requires from a year to a year and a half to mature. If, therefore, the growing season of the Louisiana cane is interferred with by a drought in May which sometimes happens, or a drought in August, which sometimes happens, or even a drought in September, there is simply no opportunity for the cane to produce a yield. If this same cane could have been watered and kept from freezing, it would have produced probably double what it will cut actually on November 1st. The average of cane per acre in Louisiana has been variously estimated at from sixteen to eighteen tons per acre. Certainly twenty tons is a liberal estimate. Now in the irrigation experiments conducted at the Park on a very small scale, of course, the tonnage ran from forty to sixty, and I believe that there should be no difficulty in getting fifty tons of cane on an acre of good Louisiana land provided we can control the water supply exactly.

An experiment on irrigation has been planned in East Baton Rouge Parish on a one-acre field of D 74 fall plant cane. One-half of this is to be irrigated and the other portion is to be left unirrigated to serve as a check. This cane is on Laurel Plantation, which is nearly all in rice, making it easy to obtain the water required. The field is now in readiness for irrigation in case a drought should set in. The water will be measured and the cost of irrigation and the increase in tonnage determined.

VARIETIES.

We have just listened to Mr. Taggart's description of the particularly promising Louisiana seedling L 511. If this cane fulfills in actual plantation experience the promise it shows in experimental work at the Park, it may serve to solve once for all the problem of the Louisiana sugar competing with tropical sugar. In some experiments L 511 produced 30 tons to the acre of a cane which would yield easily 200 pounds of sugar to the ton, or probably more. With these rather remarkable results in view it becomes all the more necessary to verify them on the plantations. Now, in going over the sugar parishes I have noticed a very considerable lack of interest in the improvement of cane varieties. Mr. Taggart has distributed quite a quantity of L 511 to plantations in the sugar district, but in the majority of cases the cane has been neglected and the experiment has not been given a fair trial. In some cases the seed cane was allowed to dry up and was not planted according to instructions, the tarred ends were not cut off and naturally the cane either germinated in a weak condition or failed to come up. In other cases where a stand was secured a small patch was forgotten in the rush of the grinding season and was cut and ground with the rest of the cane before any results were obtained. In not one single instance have I been able to get results which I can rely upon as representing plantation conditions. Let me repeat, gentlemen, that this is one of the most important possibilities of the entire Louisiana sugar industry and I urge the planters to give more attention to seedling varieties and to work with the Station to the extent of propagating the seedling as soon as possible, so that comparisons may be made with the standard varieties on a basis of actual field conditions.

It was too late this year for me to do anything personally in helping in this line, but I hope next fall to be able to follow up these experiments. It might be advantageous to get one man who would give his entire time to the matter.

I would be very glad in closing if you gentlemen will allow me to state again the main purpose of this extension work. We wish first of all to learn the planters' problems. Where these problems have already been solved, we wish to tell the planters what the solution is, and where the problems have not been solved, we wish to take the problems up with some competent specialist in full confidence that in the course of time their work will justify itself here as it has done elsewhere in applied science.

[J. A. V.]

Mosaic Disease Found in Cuba.*

A matter of unusual interest and importance to the sugar planters and one which may seriously affect Cuba's future production, has been the definite announcement on the part of investigators that the "mosaic" disease† of the cane,

* From "News of the Cuban Sugar Industry," by H. O. Neville, in Facts About Sugar, 9:4, July 5, 1919.

† Yellow Stripe disease.

now so prevalent in Porto Rico, is present in Cuba, it having been found at Central Soledad, near Cienfuegos, and also at the experiment station at Santiago de las Vegas. Its presence at Soledad has been suspected for a considerable period, but its effects have not been felt severely, so that no attempt was made to investigate it until recently. Immediately upon being found at the experiment station, all diseased canes and canes close by which might possibly have become contaminated, were dug up and destroyed.

From a description of this disease obtained from one of the agricultural authorities of Porto Rico, Prof. F. S. Earle, now employed by the sugar interests of that island, it is understood that the symptoms are a change from the usual green color of the leaf of the cane to a mottled color caused by loss of the green matter, resulting in a striking appearance noticeable even at a distance. As the disease continues its course, the joints of the canes begin to dry up and to crack, presenting every appearance of frost bite or of canes cut down and allowed to lie in the field till dry.

CAUSE OF DISEASE UNKNOWN.

The strength of the cane stool and its reproducing powers gradually weaken, and the sugar content and juice content of the cane become continually less, until in the second or third year what cane is produced by the fields is practically valueless. It is reported that the sugar production of some of Porto Rico's mills has been reduced as much as 50 per cent by this disease. Fortunately, however, the soil in which diseased canes have grown does not seem to become contaminated, and the disease can be destroyed by taking up the affected canes and allowing them to be dried thoroughly by the sun.

To date no one knows either the cause of the disease or the method by which it spreads. In some years it is apparently very benign in its effect, and almost no tendency to spread is shown, but in other years it spreads with great rapidity, often appearing in locations four or five miles away from other previously affected areas. Publicity is being given the matter in Cuba, and it is expected that Congress will be asked to grant an appropriation to the Department of Vegetable Sanitation, with which to carry out a thorough inspection of the island and take the necessary action to stamp out the disease wherever found.